
HONI SOI
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The Marquis of Stafford.

PHYTOLOGIA;

OR THE

PHILOSOPHY

OF

AGRICULTURE

AND

GARDENING.

WITH THE THEORY OF DRAINING MORASSES,

AND WITH AN

IMPROVED CONSTRUCTION OF THE DRILL PLOUGH.

By ERASMUS DARWIN, M.D. F.R.S.

AUTHOR OF ZOONOMIA, AND OF THE BOTANIC GARDEN.

Suadent hæc CREATORIS leges a ſimplicibus ad compoſita. LIN. ORD. NAT.

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DEDICATION.

To Sir John Sinclair, Baronet, to whose unremitted exertions, when President of the Board of Agriculture, many important improvements in the cultivation of the earth were accomplished and recorded; this Work, which was began by the instigation of his letters to the author, is dedicated with great respect.

Derby, Jan. 1, 1799.

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INTRODUCTION.

Agriculture and Gardening, though of ſuch great utility in producing the nutriment of mankind, continue to be only Arts, conſiſting of numerous detached facts and vague opinions, without a true theory to connect them, or to appreciate their analogy; at a time when many parts of knowledge of much inferior conſequence have been nicely arranged, and digeſted into Sciences.

Our imperfect acquaintance with the phyſiology and economy of vegetation is the principal cauſe of the great immaturity of our knowledge of Agriculture, and Gardening. I ſhall therefore firſt attempt a theory of vegetation, deduced principally from the experiments of Hales, Grew, Malpighi, Bonnet, Du Hamel, Buffon, Spallanzani, Prieſtley, and the Philoſophers of the Linnæan School, with a few obſervations and opinions of my own; ſome of which have in part already appeared in Zoonomia, and in the notes to the Botanic Garden, but are here corrected and enlarged. To the former of which works I hope this may be eſteemed a ſupplement, as it is properly a continuation of the ſubject.

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My inducement to commence this work, after it was ſuggeſted to me by the letters of Sir John Sinclair, was a belief, that the experiments and obſervations already made on the growth of plants, with the modern improvements in chemiſtry, were ſufficiently numerous and accurate for the eſtabliſhment of a true theory of vegetation; ſo much wanted to connect the various facts in the memory, to appreciate their value, and to compare them with each other; and finally to direct the proſecution of future experiments to uſeful purpoſes.

PHYTOLOGIA.

PART THE FIRST.

PHYSIOLOGY OF VEGETATION.

SECT. I.

THE INDIVIDUALITY OF THE BUDS OF VEGETABLES.

1. *Vegetables are inferior animals. A bud torn from a tree will grow; vines and hawthorns ſo planted. Many kinds of fruit ingrafted on one tree.* 2. *The bark and branches of hollow-trees remain alive. Caudex of herbaceous plants. Caudex of buds.* 3. *Which deſcending, form a new bark over the old one. Theſe bark veſſels occaſionally inoſculate. Upper lip of wounds of the bark grows downwards.* 4. *Flower-buds are individual beings; do not ſo certainly grow by inoculation as leaf-buds; are biennial plants like leaf-buds, but die in autumn without enlarging the ſize of the tree by their progeny.* 5. *In what vegetables differ from animals; they have not muſcles of locomotion; nor organs of digeſtion.* 6. *In what they reſemble animals. They have abſorbent, umbilical, placental, and pulmonary veſſels, arteries, glands, organs of reproduction, with muſcles, nerves, and brain.* 7. *Progreſs of a young bud, and of a ſeed. The plumula, radicle, and caudex of a bud.* 8. *Buds and ſeeds are biennial beings. How they differ. The diſunion of the pith diſtinguiſhes buds from each other, and thus evinces their individuality.*

1. WE have ſo accuſtomed ourſelves to conſider life and irritability to be aſſociated with palpable warmth and viſible motion, that we find a renitency in ourſelves to aſcribe them to the comparatively cold and motionleſs fibres of plants. But to reaſon rightly on many vegetable phenomena we ſhall find it neceſſary firſt to ſhew, that vegetables are in reality an inferior order of animals.

If a bud be torn from the branch of a tree, or cut out and planted

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in the earth with a glafs cup inverted over it, to prevent the exhalation from being at firft greater than its power of abforption ; or if it be inferted into the bark of another tree, it will grow, and become a plant in every refpect like its parent. This evinces that every bud of a tree is an individual vegetable being ; and that a tree therefore is a family or fwarm of individual plants, like the polypus, with its young growing out of its fides, or like the branching cells of the coral-infect.

The prefent moft approved method of propagating vines in hot-houfes confifts in cutting off a fingle eye of a vine-ftalk with about an inch of the ftem above the eye, and two or three inches below it ; and fetting this aflant in the bark-bed with the eye about an inch or lefs beneath the furface, pointing upwards ; and I have feen a quick-fet or hawthorn hedge, cretægus, propagated in the fame manner by planting twigs in the ground with one bud only above the foil.

Mr. Barns, in a treatife on Propagating Fruit-trees (1759, Baldwin, London) afferts, that he cut a branch into as many pieces, as there were buds or leaves upon it ; and wiping the two wounded ends dry, he quickly applied to each a cement previoufly warmed, which confifted chiefly of pitch, and planted them in the earth with unfailing fuccefs. The ufe of this cement I fufpect to confift in its preventing the bud from bleeding to death, though the author afcribes it to its antifeptic quality. And laftly, in the inoculation and ingrafting of fruit-trees, five or fix different kinds of pears are frequently feen on the branches of one tree, which could not then properly be termed an individual being.

2. When old oaks, or willows, lofe by decay almoft all their folid internal wood, it frequently happens, that a part of the fhell of the ftem continues to flourifh with a few healthy branches. Whence it appears, that no part of the tree is alive but the buds, and the bark, and the root-fibres ; that the bark is only an intertexture of the cau-

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dexes of the numerous buds, as they paſs down to ſhoot their radicles into the earth; and that the ſolid timber of a tree ceaſes to be alive; and is then only of ſervice to ſupport the numerous family of buds in the air above the herbaceous vegetables in their vicinity.

A bud of a tree therefore, like a vegetable ariſing from a ſeed, conſiſts of three parts; the plumula or leaf, the radicle or root-fibres, and the part which joins theſe two together; which is called the caudex by Linneus when applied to intire plants; and may, therefore, be termed caudex gemmæ when applied to buds.

In herbaceous plants the caudex is generally a broad flat circular plate, from which the leaf-ſtem aſcends into the air, and the radicles or root-fibres deſcend into the earth. Thus the caudex of a plant of wheat lies between the ſtem and the radicles, at the baſis of the lowermoſt leaf, and occaſionally produces new ſtems and new radicles from its ſides. Thus the caudex of the tulip lies beneath the principal bulb, and generates new ſmaller bulbs in the boſom of each bulb-leaf, beſides one principal or central bulb; the caudex of orchis, and of ſome ranunculuſes, lies above their bulbous roots; whereas the caudexes of the buds of trees conſtitute the longitudinal filaments of the bark, reaching from the plumula or apex of the bud on the branch to the baſe of it, or its root-fibres beneath the ſoil.

Nor is this elongation of the caudexes of the buds of trees unanalogous to what happens to ſome herbaceous plants, as in wheat; when the grain is buried two or three inches beneath the ſoil, an elongation of the caudex occurs almoſt up to the ſurface, where another ſet of fibrous roots are protruded, and the upright ſtem commences. The ſame happens to tulip-roots when planted too deep in the earth, as I have witneſſed, and I ſuppoſe to thoſe of many other vegetables.

This caudex of the buds of trees not only deſcends as above deſcribed, but alſo aſcends from each bud to that above it; as on the long ſhoots of vines, willows, and briars; in this reſpect reſembling the wires of ſtrawberries and other creeping plants. Thus the caudex of perennial herbaceous plants conſiſts of a broad plate, buried beneath the ſoil to protect it from the froſt; while the caudex of buds of trees conſiſts of a long vaſcular cord extending from the bud on the branch to the radicle beneath the earth, and endures the winter froſts without injury.

3. Theſe buds are properly biennial plants, as they are generated in one ſummer, and in the next either produce ſeeds and die, or produce other buds, whoſe caudexes form a new bark over the former one, that of the laſt year firſt becoming a ſofter or more porous wood, called alburnum, or ſap-wood, and gradually hardening into ſolid timber, which ceaſes to poſſeſs vegetable life.

Theſe long caudexes of the individual buds of trees, which conſtitute their bark, are well ſeen in the cloth made from the mulberry-bark brought from Otaheite. On inſpecting this cloth the long fibres are ſeen in ſome places to adhere, where it is probable they occaſionally inoſculate, like ſome of the veſſels in animal bodies; becauſe when ſome buds are cut off, the neighbouring ones flouriſh with greater vigour, being ſupplied with more of the nutritious juices.

This informs us why the upper lip of an horizontal wound made in the bark of a tree grows downwards with ſo much greater expedition than the under one grows upwards to meet it; as the deſcending caudexes of the individual buds are ſupplied directly with nutriment from the vegetable arteries after the oxygenation of the blood in their leaves; whereas the under lip of the wound is nouriſhed only by the lateral or inoſculating veſſels, which ſupplies us with another argument againſt the individuality of trees, and in favour of that of buds.

4. The buds producing flowers are each an individual being as well

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as the leaf-buds above deſcribed, though they are probably not ſo eaſily capable of tranſplantation into the bark of other trees by inoculation; as, I believe, it is from the miſtake of the gardeners in chooſing flower-buds inſtead of leaf-buds to inoculate with, that ſo many buds die in this mode of propagation. Nor does the exiſtence of many male and female parts in one flower deſtroy its individuality any more than the number of paps of a ſow or bitch, or the number of their cotyledons, each of which during geſtation belongs to a ſeparate fetus.

The flower-buds as well as the leaf-buds are properly biennial plants, as they are produced in the ſummer of one year, and periſh in the autumn of the next; but as the new buds generated by leaf-buds continue to adhere to the parent, they are furniſhed with their numerous caudexes, which form a new bark over the old one, whereas the flower-buds generate ſeeds, which when mature fall upon the ground, and thus they die in the autumn without increaſing the ſize of the parent-tree by the adheſion of their progeny like the leaf-buds.

5. Theſe buds of plants, which are each an individual vegetable being, in many circumſtances reſemble individual animals; but as animal bodies are detached from the earth, and move from place to place in ſearch of food, and take that food at conſiderable intervals of time, and prepare it for their nouriſhment within their own bodies, after it is taken; it is evident, that they muſt require many organs and powers, which are not neceſſary to a ſtationary bud. As vegetables are immoveably fixed to the ſoil, from whence they draw their aliment ready prepared, and this uniformly, and not at returning intervals; it follows, that in examining their anatomy we are not to look for muſcles of locomotion, as legs and arms; nor for organs to receive and prepare their aliment as a mouth, throat, ſtomach, and bowels, by which contrivances animals are enabled to live many hours without new ſupplies of food from without.

6. The parts, which we may expect to find in the anatomy of vegetables,

vegetables, which correfpond to thofe in the animal economy, are firft a threefold fyftem of abforbent veffels, one branch of which is defigned to imbibe the nutritious moifture of the earth, as the lacteals imbibe the chyle from the ftomach and inteftines of animals; another to imbibe the water of the atmofphere, opening its mouths on the cuticle of the leaves and branches, like the cutaneous lymphatic veffels of animals; and a third to imbibe the fecreted fluids from the internal cavities of the vegetable fyftem, like the cellular lymphatics of animals.

Secondly, in the vegetable fetus, as in feeds or buds, another fyftem of abforbent veffels is to be expected, which may be termed umbilical veffels, as defcribed in Sect. III. of this work, which fupply nutriment to the new bud or feed, fimilar to that of the albumen of the egg, or the liquor amnii of the uterus; and alfo another fyftem of arterial veffels, which may be termed placental ones, correfponding with thofe of the animal fetus in the egg or in the womb, which fupply the blood of the embryon with due oxygenation before its nativity.

Thirdly, a pulmonary fyftem correfpondent to the lungs of aerial animals, or to the gills of aquatic ones, by which the fluid abforbed by the lacteals and lymphatics may be expofed to the influence of the air. This is done by the leaves of plants, or the petals of flowers; thofe in the air refembling lungs, and thofe in the water refembling gills.

Fourthly, an arterial fyftem to convey the fluid thus elaborated to the various glands of the vegetable for the purpofes of its growth, nutrition, and fecretions; and a fyftem of veins to bring back a part of the blood not thus expended.

Fifthly, the various glands which feparate from the vegetable blood the honey, wax, gum, refin, ftarch, fugar, effential oil, and other fecretions.

Sixthly, the organs adapted to the lateral or viviparous generation of of plants by buds, or to their ſexual or oviparous propagation by ſeeds.

Seventhly, longitudinal muſcles to turn their leaves to the light, and to expand or cloſe their petals or their calyxes; and vaſcular muſcles to perform the abſorption and circulation of their fluids, with their attendant nerves, and a brain, or common ſenſorium, belonging to each individual ſeed or bud; to each of which we ſhall appropriate an explanatory ſection.

7. An embryon bud, therefore, whether it be a leaf-bud or a flower-bud, is the viviparous offspring of an adult leaf-bud, and is as individual as a ſeed, which is its oviparous offspring. It conſiſts, firſt, of a central organization or caudex like the corculum of a ſeed, which contains the rudiments of arteries, veins, abſorbent veſſels, and glands, with an internal pith or brain.

Secondly, it is furniſhed with a ſyſtem of umbilical veſſels, which are inſerted into the alburnum or ſap-wood of the tree, or form a part of it, and deſcending into the earth ſupply it in the early ſpring with its firſt nutrition, like the ſeminal roots, ſo called, which paſs from the corculum of the ſeed, and are ſpread on the cotyledons, as ſeen in the garden bean, repreſented in Plate I. Fig. 1. which is taken from Dr. Grew's Anatomy of Plants.

Thirdly, this umbilical ſyſtem probably contains alſo what may be termed a placental artery, terminating on the coats of the lateral air-veſſels, which penetrate the bark of trees horizontally, for the purpoſe of oxygenating the blood of the vegetable fetus, like thoſe diſtributed from the umbilical veſſels of the chick on the air-bag at the broad end of the egg. See Sect. II. 4. and III. 1—4.

Fourthly, it contains the rudiments of organs adapted to lateral generation or the production of new buds; or to ſexual propagation, and the conſequent production of ſeeds.

In the early ſpring the umbilical veſſels ſupply the embryon buds of trees with ſap-juice, which is then ſeen to exſude from wounds of

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the alburnum, as in the vine, vitis; the birch, betula; and the maple, acer; which I ſuppoſe to become oxygenated in the circulation of the vegetable fetus by the horizontal air-veſſels of the bark.

As the ſeaſon advances, the leaf-bud puts forth a plumula, like a ſeed, which ſtimulated by the oxygen of the atmoſphere riſes upwards into leaves to acquire its adapted pabulum, which leaves conſtitute its lungs; it alſo protrudes from its long caudex, which forms the new bark over the old one, a radicle, which ſtimulated by moiſture paſſes downwards, and deſcends into the earth to acquire its adapted pabulum; and it thus becomes an adult vegetable being with the power of producing new buds.

The flower-bud under ſimilar circumſtances puts forth its bractes or floral-leaves, which ſerve the office of lungs to the pericarp and calyx; and expands its petals, which ſerve the office of lungs to the anthers, and ſtigmas, which are the ſexual organs of reproduction, and which die and fall off, when the ſeed is impregnated; and thus, like the leaf-bud, it becomes an adult vegetable being with the power of producing ſeeds.

8. As the flower-bud produces many ſeeds during the ſummer, ſo the leaf-bud produces many budlets during the ſummer, as may be ſeen in the long ſhoots of the vine and willow, vitis et ſalix. In this climate both the buds and ſeeds are properly biennial vegetables; that is, they are produced in one ſummer, and periſh in the next. But the ſeed differs from the bud in this circumſtance, that it drops on the earth, and is thus ſeparated from its dead parent in the autumn; whereas the bud continues to adhere to its dead parent, and grows over it as it advances.

Now as the internal pith of a bud appears to contain or produce the living principle, like the brain and medulla oblongata, or ſpinal marrow of animals, we have from hence a certain criterion to diſtinguiſh one bud from another, or the parent bud from the numerous budlets,

PLATE I.

PLATE I.

Fig. 1. reprefents the umbilical veffels fpread on the lobes of a bean, when it begins to vegetate, as mentioned in Sect. I. 7. but more particularly defcribed in Sect. III. 1. 3; which are believed to confift of a fyftem of abforbent veffels, and another fyftem of placental veffels, for the purpofe of acquiring nutriment, and of oxygenating the vegetable blood. The plate is copied from Grew, Tab. I. *f.* 14. *a* the plumula, *b* the corculum, *c c* the lobes. See Sect. I. 7. and III. 1. 3.

Fig. 2. is copied from Malpighi, Tab. II. Fig. 6, and reprefents the longitudinal fibres of the bark of willow, which adhere together, and feparate from each other alternately, with horizontal apertures between them; which are believed to be air-veffels, for the purpofe of oxygenating the blood of the embryon buds, like the air-bag at the broad end of an egg. *b b b* are the longitudinal filaments of the bark, *a a a* are the horizontal perforations.

Duhamel obferved by a microfcope fimilar apertures of different diameters in the bark of oak; the fmaller ones he believed to be the excretory ducts of the perfpirable matter, and larger ones I fuppofe to be air-veffels. The extremities of fome of thefe in the birch-tree ftood above the level of the cuticle. Phyfique des Arbres, Plate I. Fig. 7. and 11. See Sect. I. 7. and II. 4. of this work.

Plate I.

Fig. 1.

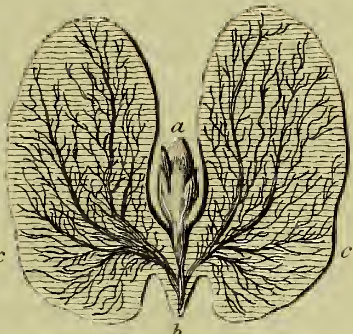


Fig. 2.

London, Published Jan.y 1.st 1800, by J. Johnson, St Paul's Church Yard.

budlets, which are its offspring, as *there is no communication of the internal pith between them.*

This obfervation was made by flitting the young branches of horfe-chefnut, æfculus hippocaftanum; of afh, fraxinus; of willow, falix; and of elder, fambucus nigra; and I plainly difcerned that there exifted no communication of pith between the lateral budlets and their parent fhoots, or between the central larger budlet at the fummit of the branch, and its parent fhoot. This alfo afforded me one reafon to conclude that the different joints of wheat, triticum, of fouthiftle, fonchus, and of teafel, dypfacus, are different buds growing on each other, thofe at the fummit only producing feeds; becaufe there is a divifion which feparates the pith contained in each joint of their hollow ftems, as is further explained in Sect. IX. 2. 4. and 3. 1. and which perfectly evinces the individuality of buds.

SECT. II.

THE ABSORBENT VESSELS OF VEGETABLES.

1. *Roots, leaves, bark, ſap-wood, ſhewn to abſorb by not moiſtening them, by placing them in water.* 2. *Abſorbent veſſels coloured by a decoction of madder, by dilute ink. They form a ring in the ſap-wood beneath the bark, with a ring of arteries exterior to them.* 3. *Abſorbents erroneouſly believed to be air-veſſels, are viſibly full of ſap-juice in a vine-ſtalk. Vegetable veſſels have rigid ſides, which do not collapſe, and hence become full of air when cut; not ſo in animal veſſels.* 4. *Some horizontal veſſels in trees are truly air-veſſels for the embryon bud, like the air in the broad end of the egg.* 5. *Abſorbent veſſels conſiſt of long cylinders; air will paſs through them either way in the dead vegetable; are not reſpiratory organs, as they exiſt in the roots of trees. May receive air diſſolved in water.* 6. *Abſorbent veſſels act either direct or retrograde. A forked branch in water. An inverted tree. A ſuſpended tree. So in the operation of an emetic, and in ruminating cows.* 7. *They conſiſt of a ſpiral line without valves; and by its vermicular contraction forcibly carry on their contained fluids either way.* 8. *Thoſe of the root act occaſionally in winter; but vines in hot-houſes muſt have their roots guarded from froſt in ſpring. Accumulated ice deſtroys trees in ſpring.* 9. *They ſometimes abſorb poiſonous fluids, as ſpirit of wine, ſolution of arſenic, vitriolic acid; roots ſaid to creep aſide from bad ſoil erroneous.* 10. *Abſorbents of trees like the receptacle of chyle.*

1. The exiſtence of that branch of the abſorbent veſſels of vegetables, which reſembles the lacteals of animal bodies, and imbibes their nutriment from the moiſt earth, is evinced by their growth, ſo long as moiſture is applied to their roots, and their quickly withering when it is withdrawn.

Beſides

Befides thefe abforbents in the roots of plants there are others, which open their mouths on the external furfaces of the bark and leaves to abforb the moifture of the atmofphere, refembling the cutaneous lymphatics of animal bodies; the exiftence of thefe is fhewn, becaufe a leaf plucked off and laid with its under fide on water will not wither fo foon as if left in the dry air. The fame if the bark alone of a branch, which is feparated from a tree, be kept moift with water.

A third branch of abforbent veffels opens its mouths on the internal furfaces of the cells and cavities of the vegetable fyftem to abforb the fecreted fluids, after they have performed their adapted offices, fimilar to the cellular lymphatics of animal bodies, as may be fhewn by moiftening the alburnum or fap-wood, and the internal furface of the bark of a branch detached from a tree, which will not then fo foon wither as if left in the dry air unmoiftened.

Another means of demonftrating the abforbent powers of the parts of vegetables is by inferting them into glafs tubes, or into tall narrow veffels filled with water, and obferving how much more rapidly the furface of the water fubfides than in fimilar veffels by evaporation alone.

2. By the following experiment thefe vegetable abforbent veffels were made agreeably vifible by a common magnifying glafs. I placed in the fummer of 1781 fome twigs of a fig-tree with leaves on them about an inch deep in a decoction of madder (Rubia tinct), and others in a decoction of logwood (hæmatoxylum campechenfe), along with fome fprigs cut off from a plant of picris. Thefe plants were chofen becaufe their blood is white. After fome hours, and on the next day, on taking out either of thefe, and cutting off from its bottom about an eighth of an inch of the ftalk, an internal circle of red points appeared, which I believed to be the ends of abforbent veffels coloured red with the decoction, and which probably exifted in the newly formed alburnum, or fap-wood, while an external ring of arteries was

ſeen to bleed out haſtily a milky juice, and at once evinced both the abſorbent and arterial ſyſtem.

Many ſimilar experiments were made by M. Bonnet, by placing parts of the ſtem or roots of various vegetables, as of kidney-beans, peach-tree, and elder, in dilute ink; in all theſe the veſſels of the bark were uncoloured, and thoſe of the pith; but thoſe beneath the bark, which he terms woody, were coloured black, which I ſuppoſe to have been the circle of abſorbent veſſels above mentioned. Uſage de Feuilles, Plate XXIX.

3. Theſe abſorbent veſſels have been called bronchia by Malpighi and Grew, and ſome other philoſophers, and erroneouſly thought to be air-veſſels; in the ſame manner as the arteries of the human body were ſuppoſed to convey air by the antients, till the great Harvey by more exact experiments and juſter reaſoning evinced, that they were blood-veſſels. This opinion has been ſo far credited becauſe air is ſeen to iſſue from wood, whether it be green or dry, if it be covered with water, and placed in the exhauſted receiver of an air-pump; and theſe veſſels have therefore been ſuppoſed to conſtitute a vegetable reſpiratory organ; but it will be ſhewn hereafter, that the leaves of plants are their genuine lungs, and that the abſorbent veſſels and arteries become accidentally filled with air in the dead parts of vegetables.

For as the veſſels of vegetables are very minute, and have rigid coats, their ſides do not collapſe when they are cut or broken, as their juices flow out or exhale; they muſt therefore receive air into them. This may be readily ſeen by inſpecting with a common lens the end of a vine-ſtalk two or three years old, when cut off horizontally. At firſt the veſſels, which are ſeen between the partitions radiated from the center, appear full of juice; but in a minute or leſs this juice either paſſes on, or exhales; and the veſſels appear empty, that is filled with air. This experiment I have twenty times repeated with

with uniform fuccefs, and it is fo eafily made by haftily applying a common lens after the divifion of a vine-ftalk, that I think there can be no error in it; and it is wonderful that thefe veffels, which are found in the alburnum, and confift of a fpiral line, whether they may properly be called abforbent or umbilical veffels, or confift of both, fhould ever have been fuppofed to be air-veffels.

There is neverthelefs an experiment by Dr. Hales, which would at firft view countenance the affertion, that vegetables abforb air. He cemented the lower end of a fmall twig of a tree with leaves on it into a glafs tube about four inches long, and fet the other end of the tube an inch deep in water, and obferved in a little time, that the water rofe an inch in the tube; but this muft happen from the vegetable veffels emptying themfelves by the afcent of their juices, and having rigid coats, and therefore not contracting, a portion of the air was forced into them by the preffure of the atmofphere, as in the above obfervation on the vine-branch cut horizontally.

This reception of air does not happen to the veffels of animal bodies, when they are emptied of their blood, owing to the lefs rigidity of their coats; whence the weight of the atmofpheric air preffes their fides together, and clofes the veffel, inftead of paffing into it. In the fame manner no air would pafs into the veffels of the lungs of animals in refpiration, unlefs the preffure of the atmofphere on their fides was prevented by the action of the mufcles, which enlarge the cavity of the thorax by elevating the ribs.

4. There are neverthelefs certain horizontal veffels of large diameter, which pafs through the bark of trees to the alburnum, which probably contain air, as they are apparently empty, I believe, in the living vegetable; for the bark of trees confifts of longitudinal fibres, which are joined together, and appear to inofculate at certain diftances, and recede from each other between thofe diftances like the mefhes of a net, in which fpaces feveral horizontal apertures are feen to penetrate through the bark to the alburnum, according to Malpighi,

 who

who has given a figure of them, which is copied in Plate I. Fig. 2. of this work. Very fine horizontal perforations through the bark of trees are alſo mentioned by Duhamel, which he believes to be perſpiratory or excretory organs, but adds, that there are others of much larger diameter, ſome round and ſome oval, and which in the birch-tree ſtand prominent, and pierce the cuticle or exterior bark. Phyſique des arbres, T. 1. Tab. III. Fig. 8. and 11.

Theſe veſſels probably contain air during the living ſtate of the tree, as they pierce the external bark, which frequently conſiſts of many doubles, like a roll of linen cloth; as a new cuticle is annually produced beneath the old one, like a new ſcarf-ſkin beneath a bliſter in animal bodies; and the old one ſometimes continues, and ſometimes peels off like the cuticle of a ſerpent, as is ſeen on the trunks of many cherry-trees and birches. Theſe veſſels, when contracted in dry timber, appear like horizontal inſertions in many planed boards, in which the ſpiral abſorbent veſſels become by their contraction the longitudinal fibres, as appears in the figure of a walking cane given by Dr. Grew, Tab. XX.

Theſe horizontal veſſels I ſuppoſe to contain air incloſed in a thin moiſt membrane, which may ſerve the purpoſe of oxygenating the fluid in the extremities of ſome fine arteries of the embryon buds, in the ſame manner as the air at the broad end of the egg is believed to oxygenate the fluids in the terminations of the placental veſſels of the embryon chick, as further noticed in Sect. III. 2. 6. and III. 1. 4.

5. The abſorbent veſſels of trees in paſſing down their trunks conſiſt of long hollow cylinders, whoſe ſides I believe to be compoſed of a ſpiral line, and are of ſuch large diameters in ſome vegetables as to be viſible to the naked eye, when they become dry and empty, as in cane. Air will rapidly paſs through theſe veſſels in either direction, as may be ſeen in lighting a cane ſome inches long at either end, and drawing the ſmoke through the pores of it into the mouth, as through a tobacco-pipe. Dr. Hales readily paſſed both air and water through

a recent

a recent vegetable ſtick both upwards and downwards, by ſetting one end of it in a cup of water in the receiver of an air-pump, and exhauſting the air, Veg. Stat. p. 154; whence he concludes with Grew, that theſe are air-veſſels or lungs for the purpoſe of reſpiration, and that they receive atmoſpheric air in their natural ſtate.

There is one objection to their uſe as air-veſſels, which is, that they have no communication with the horizontal air-veſſels above deſcribed; for by blowing forcibly through a piece of dry cane immerſed deep in water, no air is ſeen to bubble out of the ſides, but only from the bottom of it. It may indeed be ſuppoſed, that the longitudinal cavities in dry cane may not conſiſt of the abſorbent veſſels above deſcribed, but of the interſtices between them, as the coats of thoſe abſorbent veſſels, conſiſting of a ſpiral line, may be thought to cloſe up by their vermicular contraction; and their interſtices, conſiſting of vegetable cellular membrane, may be ſuppoſed, when dry, to become the tubes in cane. But in this caſe the longitudinal canals in dry cane would not be circular cylinders, whereas they are ſo repreſented in a figure of a piece of cane much magnified by Dr. Grew, Tab. XX. who has in the ſame figure given the mouths of horizontal air-veſſels of circular form and larger diameter.

But there is another inſuperable objection to this idea of their uſe, which is, that theſe veſſels equally exiſt in the roots of plants as in their trunks; and according to Malpighi with larger diameters; and probably terminate externally only in the roots; and, as they are there not expoſed to the atmoſphere, they cannot ſerve the purpoſe of reſpiration; air neverthelefs in its combined ſtate, or even as diſſolved in water, may be abſorbed by theſe veſſels; and may appear, when the preſſure of the atmoſphere is removed in the exhauſted receiver; or when expanded by heat, as is ſeen in the froth at one end of a green ſtick, when the other end is burning in the fire.

6. Theſe vegetable abſorbents differ from thoſe of animals in the facility, with which they carry their fluids either way; for a forked branch

branch of a tree, torn from its trunk, and having one of its forks with the leaves on it inverted in a veſſel of water, will continue for ſeveral days unwithered, nearly as well as if the whole had been placed upright in the water. A willow rod on the ſame account will grow almoſt equally well, whether the apex or baſe of it be ſet in the ground; and Dr. Bradley, I think, mentions a young gooſeberry-tree having been taken up, and replanted with its branches in the earth, and its roots in the air; and that the branches put forth root-fibres, and the roots put forth leaf-buds. There is likewiſe a curious experiment by Dr. Hales, who attached the eaſtern branch of a young tree to its neighbour by inarching, and its weſtern branch to another of its neighbours in the ſame manner; and after they were united, he cut the ſtem of the middle tree from its root, and thus left it hanging in the air by its two inarched arms, where it flouriſhed with conſiderable vigour.

This power of carrying their fluid contents in a retrograde direction is alſo poſſeſſed in ſome degree by the abſorbents of animals, particularly in their diſeaſed ſtate, and even in the operation of an emetic, as ſhewn in Zoonomia, Vol. I. Sect. 29; and is viſible in the œſophagus or throat of cows, who convey their food firſt downwards, and afterward upwards by a direct and retrograde motion of the annular cartilages, which compoſe the gullet, for the purpoſe of rumination.

7. The ſtructure of theſe large vegetable abſorbents, erroneouſly called air-veſſels, probably conſiſts of a ſpiral line, and not of a veſſel interrupted with valves, and differs in this conſtruction from animal lymphatics; for firſt, on breaking almoſt any tender vegetable, as a laſt year's ſprig of a roſe-tree, or the middle rib of a vine-leaf, and gradually extending ſome of the fibres, which adhere the longeſt, this ſpiral ſtructure becomes viſible even to the naked eye, and diſtinctly ſo by the uſe of a common lens, as is delineated in Duhamel's Phiſique des arbres, T. 1. Tab. II. Fig. 17, 18, 19, and in Plate LI. and

and LII. of Grew's Anatomy of Plants (fol. edit.), and by this eaſy experiment both that abſorbent ſyſtem, which imbibes nouriſhment from the earth, and brings it to the caudex of each bud; and that which imbibes moiſture from the air, and a part of the perſpirable matter on the ſurface of the leaf, and brings it to the caudex of each bud, are agreeably demonſtrated. See Plate II. Fig. 1. And that theſe veſſels of large diameter, with their ſides conſiſting of a ſpiral line, are not arteries or veins, is evinced by inſpecting a ſtem of euphorbia, ſpurge; or the ſtalk of a fig-leaf, ficus, immediately on dividing them, as the milky juice oozes from a ring of veſſels exterior to thoſe large abſorbents.

Secondly, that theſe veſſels are not furniſhed with frequent valves is countenanced by the experiments before mentioned in No. 5 of this ſection, one of which conſiſted of lighting a piece of cane, and drawing the ſmoke through it, as through a tobacco-pipe, in either direction; and the other in placing a bit of recent twig with one end of it in a cup of water in the receiver of an air-pump, and cauſing both air and water to paſs through it in either direction.

If the minuter branches of vegetable abſorbents be of a ſimilar ſtructure, it is eaſy to conceive how a vermicular or periſtaltic motion of the veſſel, beginning at the loweſt part of it, each ſpiral ring ſucceſſively contracting itſelf, *till it fills up the tube*, muſt forcibly puſh forwards its contents without the aid of valves; and if this vermicular motion ſhould begin at the upper end of the veſſel, it muſt with equal facility carry its contained fluid in a retrograde or contrary direction.

8. As the abſorbent veſſels in the roots of plants are protected from the froſt in ſome degree by the earth which covers them; they ſeem at all times to be ſufficiently alive to drink up and puſh forwards their adapted fluid, ſince if a branch of a tree is brought into a warm room, it will in general pullulate in the winter, as ſoon as the veſſels of the upper part of the branch are rendered ſufficiently irritable by warmth to act in concert with the abſorbents of the root,

 Nevertheleſs,

Neverthelefs, in fevere frofts it is neceffary to guard all the parts of the ftem which is expofed to the open air, as is experienced in the vines brought through holes into hot-houfes, otherwife after the buds are put out a fevere froft fo affects the ftems on the outfide of the houfe as to deftroy all the fruit of that year. Kenedy on Gardening, Vol. I. p. 270. And it is obferved in Mr. A. Aikin's Natural Hiftory of the Year, that much ice was carried from the ftreets in London in 1794, and piled round fome elm trees in Moorfields, many of which were deftroyed in the enfuing fpring by the flow melting of it.

9. The abforbent veffels of vegetables, like thofe of animal bodies, are liable to err in the felection of their proper aliment, and hence they fometimes drink up poifonous fluids, to the detriment or deftruction of the plant. Dr. Hales put the end of a branch of an apple-tree, part of which was previoufly cut off, into a quart of rectified fpirit of wine and camphor, which quantity the ftem imbibed in three hours, which killed one half of the tree. Veg. Stat. p. 43. Some years ago I fprinkled on fome branches of a wall-tree a very flight folution of arfenic, with intent to deftroy infects; but it at the fame time deftroyed the branches it was thrown upon. And I was informed by Mr. Wedgewood, that the fruit-trees planted in his garden near Newcaftle in Staffordfhire, which confifted of an acid clay beneath the factitious foil, became unhealthy as foon as their roots penetrated the clay; and on infpection it appeared, that the fmall fibres of the roots, which had thus penetrated the clay, were dead and decayed, probably corroded by the vitriolic acid of the clay, beneath which is a bed of coals.

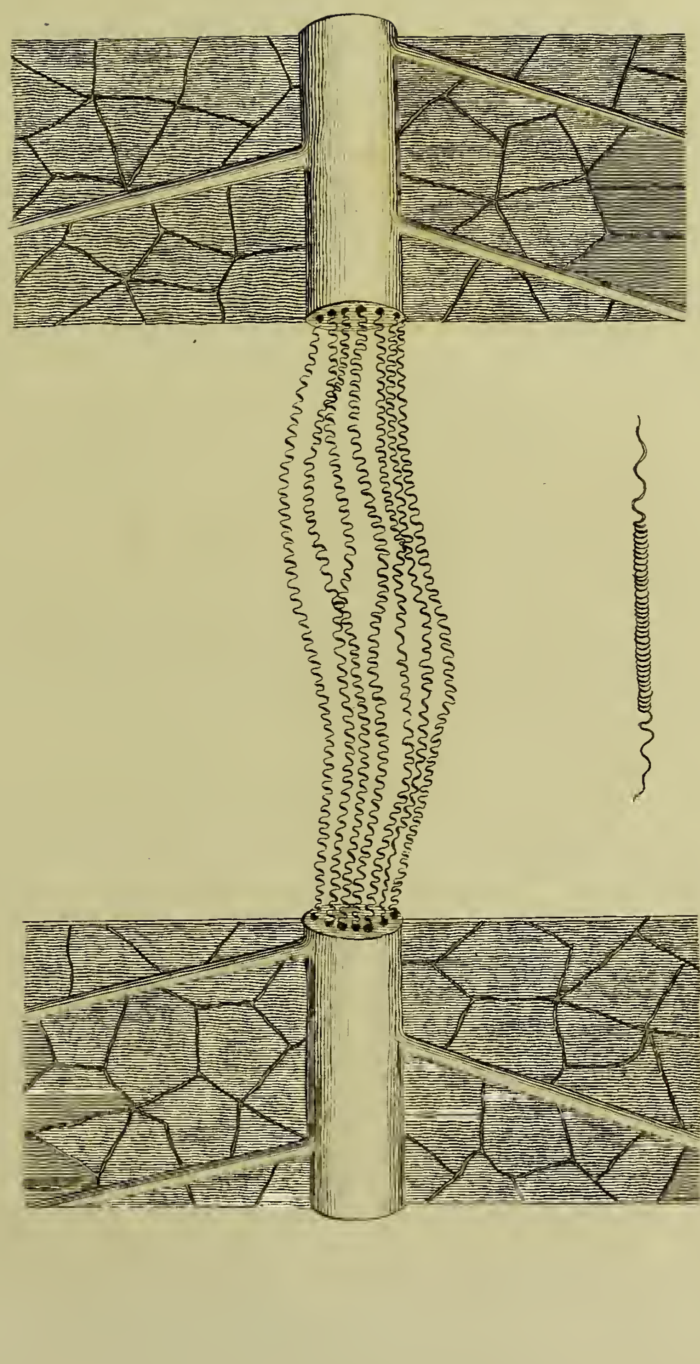
It is, however, afferted by M. Buffon, that the roots of many plants will creep afide to avoid bad earth, or to approach good. Hift. Nat. Vol. III. But this is perhaps better accounted for by fuppofing, that the roots put out no abforbent veffels, where they are not ftimulated by proper juices; and that an elongation of roots in confequence only fucceeds, when they find proper nutriment.

10. Thefe long and large cylindrical abforbent veffels, which pafs from

PLATE II.

PLATE II.

Repreſents the ſpiral veſſels of a vine-leaf conſiderably magnified, copied from Grew, Tab. LI. On ſlowly tearing aſunder almoſt any tender vegetable ſhoot or leaf, the ſpiral ſtructure of theſe veſſels becomes viſible to the naked eye. They have been erroneouſly believed to be air-veſſels; but as they exiſt equally in the roots of plants, as in their barks, and have no communication with the horizontal perforations of the cuticle of the bark, they cannot be air-veſſels, and are therefore believed to conſtitute the abſorbent veſſels of the adult vegetable, and the umbilical ones of the embryon bud. A ſimilar plate of the ſpiral ſtructure of theſe veſſels is given by Duhamel. As they are larger than the vegetable blood-veſſels, and paſs along the whole caudex of each bud from its plumula to its radicle, as well as to the cutaneous abſorbents, thoſe of the trunks of trees or herbaceous plants may be thought to reſemble the receptaculum chyli of animal bodies. See Sect. II. 7.



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from the roots of trees up to the ſummit of the caudex of each bud at the foot-ſtalk of the leaf, I ſuppoſe to be analogous to the receptacle of the chyle of animals, as the ſmall abſorbent branches of the roots probably unite beneath the ſoil into thoſe large veſſels, which are ſo eaſily viſible; hence the caudex of each bud conſiſts of an elongation of abſorbent veſſels, and of arteries and veins reaching from the union of the root-branches to the foot-ſtalk of each leaf, and the plumula of the bud in its boſom, as deſcribed in Sect. I. 7.

SECT. III.

THE UMBILICAL VESSELS OF SEEDS AND BUDS.

I. 1. Seeds *are a ſexual offspring like eggs. Some ſeeds and eggs contain two kinds of nouriſhment. Other ſeeds and ſpawn of fiſh contain but one kind of nouriſhment.* 2. *Air-bag in eggs, and in ſome fruits; not in ſeeds, nor in ſpawn.* 3. *Veſſels improperly called umbilical; thoſe properly called umbilical conſiſt of abſorbents, and a placental artery and vein. Seed embryon and chick begin their growth by the action of their abſorbents.* 4. *Seminal roots of Grew, and chorion of the chick of Malpighi, are reſpiratory organs.* 5. *In what the chick differs from the ſeed-embryon. Nothing is found in ſeeds ſimilar to the yolk of the egg.* II. 1. Buds and bulbs *are a paternal offspring; exactly reſemble their parents.* 2. *Have umbilical veſſels, in which the ſap-juice riſes in the ſpring. Why the bark is then eaſily ſeparated from the alburnum.* 3. *Sugar in the ſap-juice exiſts in the alburnum, and in roots. Dry rot of timber owing to fermentation. Why lower branches firſt pullulate.* 4. *Sap aſcends not by capillary attraction, but by the irritative motions of abſorbent veſſels. Inſtances of vegetable irritability. Abſorbent veſſels ſometimes act as capillary ſyphons, and as capillary tubes.* 5. *Umbilical veſſels coaleſce. Why trees do not bleed in ſummer.* 6. *Umbilical veſſels of buds like thoſe of ſeeds. Poſſeſs air-veſſels like thoſe of the chick. Buds, like eggs, ſeparate from the parent; their umbilical veſſels improperly called placental ones, as they convey nutriment; hence plants become dwarfs if the cotyledons of the ſeed are deſtroyed. Birch-trees die if ſmeared with oil or pitch.* 7. *Reſervoir of nutriment in the alburnum of trees, and in the roots of biennial plants. Experiment of boiling the alburnum and fermenting the liquor. As buds are formed at midſummer, they may then be tranſplanted by inoculation, but in the ſpring muſt be ingrafted, and grow by inoſculation of veſſels, like inflamed parts of animals.* 8. *A pauſe in vegetation at midſummer. New umbilical veſſels act in autumn, and the bark ſeparates eaſily as in ſpring. Honey-dew. Sap-juice riſes in winter occaſionally both in ever-*

ever-green trees and deciduous ones, and after the ſummit of the plant is cut off.
9. Umbilical veſſels and abſorbents ſeen in a vine-ſtalk, the latter exterior to the former. Exiſt in the alburnum.

I. 1. The ſeeds of vegetables are a ſexual offspring correſponding with the eggs of animals, and contain, like them, not only the rudiment of the new organization, but alſo a quantity of aliment laid up for its early nouriſhment.

The eggs of birds contain two kinds of albumen, or white, one leſs viſcid than the other, which is firſt conſumed, and the yolk or vitellum, which is drawn up into the bowels of the chick at its excluſion from the ſhell, and ſerves it for nouriſhment a day or two, till it can learn to ſelect and digeſt grains or inſects. In like manner many ſeeds are furniſhed with two kinds of nouriſhment, the mucilaginous or oily meal of the ſeed-lobes, and the ſaccharine or aceſcent pulp of the fruit, as in pears, plums, cucumbers, which ſupply nutriment to the embryon plant, till it is able to ſtrike into the earth ſufficient roots for the purpoſe of abſorbing its nutritious juices.

The ſpawn of fiſh, and of frogs, and of inſects, as of ſnails and bees, which are almoſt as innumerable as the ſeeds of plants, and are in the ſame manner excited into life by the warmth of the ſun, are analogous to thoſe ſeeds, I believe, which are not ſurrounded with fruit, and which contain but one kind of nouriſhment for the embryon plant, as grains of corn, and legumes; but perhaps theſe have not yet been ſufficiently attended to by philoſophers.

Theſe eggs of animals and ſeeds of vegetables are produced by the congreſs of male and female organs; the former ſupplying the ſpeck of animation or cicatricula in the egg, and the corculum or heart in the ſeed; and the latter producing the nidus, or neſt for its reception, and the nutritive material for its firſt ſupport. Thus the eggs of fowls are formed long before they are impregnated, and are ſometimes laid in their unimpregnated ſtate; and the ſeeds of legumes are viſible

visible many days before the flower opens, and in consequence before they are impregnated, as observed by Spallanzani.

2. The eggs of birds contain a bag of air at their broad end for the purpose of oxygenating the blood of the chick. In this one circumstance the seeds of plants seem to differ from the eggs of birds, as they contain no air-bag, though it is probable they may agree with the spawn of fish, which I suppose possess no included air. When the seeds fall on the ground in their natural state of growth, or are buried an inch or two beneath the soil, which has recently been turned over, and thus contains much air in its interstices, their coats do not continue dry like the shells of eggs during incubation, but immediately become moist membranes, like the external membrane of the spawn of fish immersed in water, and in consequence can admit the oxygenation of the air through them to an adapted set of arteries on their internal surface, according to the curious observations of Dr. Priestley on the oxygenation of the blood by the air through the moist membranes of the lungs.

It should be here observed, that many seeds, before they fall on the moist earth, are included in a bag of air, as those of the staphylea, bladder-nut; of the physalis alhekengi, winter-cherry; of colutea, bladder-senna; in the pods of peas and beans; in the cells surrounding the seeds of apples and pears; and in the receptacle of ketmia, which probably serves to oxygenate the blood of the infant seed, which in these plants may thus be of forwarder growth, before it is shed upon the soil.

3. There exists a series of glands, and their ducts, improperly called umbilical vessels by some writers, which supplies the seed with nourishment from the parent plant, so long as it adheres to the ovarium of its mother, as the vessels by which a pea adheres to the pod, in which it is included; in fruits and nuts, where the kernel is covered with a stone or shell, a long cord of vessels passes into the bottom of the stone or shell, and rising to the top bends round the lobes of the kernel,

nel, and is inferted near or into the corculum or heart of the feed, where the living principle refides, and affords not only prefent nutrition to the vegetable embryon, but alfo fecretes the farinaceous or oily materials for its future nourifhment, which conftitute the cotyledons of the feed.

But the veffels, which may be properly called umbilical, pafs from the heart or corculum of the feed, which is the living embryon of the future plant, into the feed-lobes, commonly called cotyledons, and imbibe from thence a folution of the farinaceous or oily matter there depofited for the nutriment of the new vegetable. Thefe veffels are delineated in their magnified appearance by Dr. Grew, Plate LXXIX. fol. edition, and are by him termed feminal roots. See Plate I. Fig. 1.

Thefe umbilical veffels probably confift of a fyftem of abforbents, which fupply nutriment to the embryon plant from the cotyledons of the feed, and alfo of a fyftem of placental arteries and veins fpread on the humid membrane, which covers the cotyledons, and is moiftened by its contact with the earth, for the purpofe of oxygenating the vegetable blood. This idea is countenanced by many plants bringing up their cotyledons, or feed-lobes, out of the ground into the air, which are then converted into leaves, and perform the office of lungs, after they have given up beneath the foil the nutriment, which they previoufly contained, as in the young kidney-bean, phafeolus; fo the white corol of the helleborus niger, chriftmas rofe, is changed into a green calyx by loofing one fyftem of arteries after the impregnation of the feeds.

The feed-embryon therefore refembles the chick in the egg, firft as when vivified by the influence of external warmth they both begin their growth by the abforbent fyftem of veffels being ftimulated into action by their adapted nutriment; and the fluids thus pufhed forwards ftimulate into action the other parts of the fyftem, confifting at firft principally of arteries and glands.

Secondly, they feem to refemble each other in their poffeffing each of of them an abſorbent ſyſtem of veſſels, which imbibe the nutritious matters laid up for them in the albumen or white of the egg, and in the cotyledons or lobes of the ſeed; and alſo of a placental ſyſtem of arteries for the purpoſe of oxygenating their fluids, as deſcribed above in the ſeed, and which appears in the egg to be ſpread on a membrane, which covers the white, as is ſhewn in the plates of Malpighi, and called by him the chorion, and expoſes the blood of the chick to the oxygen of the air contained at the broad end of the egg through a moiſt membrane.

4. The uſe of the large apparent artery ſpread on the cotyledons of a germinating ſeed of a garden-bean, called ſeminal roots by Grew, as ſhewn in Plate I. Fig. 1, and that ſpread on the chorion of the chick in the egg, ſo called by Malpighi, and ſhewn in Tom. II. Fig. 54, and by Fabricius ab Aquapendente, Tab. I. Fig. 13, which muſt be an artery, as it carries red blood, are believed to be reſpiratory organs, like the placental veſſels of the fetus of viviparous animals, becauſe the cotyledons of ſome ſeeds riſe out of the ground, and become leaves, after the nutriment they contained is expended, and are then called ſeminal leaves, as in the kidney-bean, phaſeolus; and becauſe thoſe which do not riſe out of the ground periſh beneath the ſoil, as ſoon as the young plant gains its leaves, which are its aerial reſpiratory organ.

Secondly, the chorion of the chick conſiſts of a membrane including the white, or albumen, and is not only in contact with the air-bag at the broad end of the egg, which, as the chick advances, covers more than half of the internal ſurface of the ſhell, but alſo with the membrane which lines all the other part of the ſhell, as appears in Plate III. which is copied from Malpighi: yet this extenſive chorion, with the numerous arteries and veins which are ſpread upon its ſurface, is not drawn up into the body of the chick like the yolk and its including membrane, but periſhes at the nativity of the chick like the placental veſſels of the fetus of viviparous animals; or ſometimes,

times, I ſuppoſe, before its nativity, as the chick perforates the air-bag, and is heard to chirp, before it is excluded from the ſhell.

Hence it would appear, that both the artery attending the ſeminal roots above mentioned, and this artery on the chorion of the chick, muſt perform ſome more important office than to ſupply nouriſhment to the coats of the abſorbent veſſels, which imbibe the mucilage of the ſeed, or the white of the egg, and which abſorbents muſt themſelves poſſeſs their proper vaſa vaſorum. And what more important office can they have than that of oxygenating the blood of the vegetable or animal embryon? And this becomes more probable as they both periſh at its nativity like the placenta and cotyledons of viviparous animals.

5. As the incubation of the chick advances, it differs from the ſeed-embryon in the production of inteſtines, with a ſtomach, on the internal ſurfaces of which the mouths of the abſorbents now terminate; and laſtly in the production of a mouth and throat to receive and ſwallow the remainder of the albumen, in which it ſwims; whereas the ſeed-embryon ſhoots down new roots into the earth with an abſorbent ſyſtem to acquire its nutriment, as that from the cotyledons of the ſeed becomes exhauſted. See Sect. VII. 1, 2.

Nor is there any thing ſimilar to the yolk of the egg found in the ſeeds of vegetables, which is drawn up into the inteſtines of the young chick about the time of its excluſion from the ſhell to ſerve it with nutriment for a day or two, till it can learn of its parent by imitation to ſelect and ſwallow its adapted food. Nor is the fetus of viviparous animals furniſhed with any thing ſimilar to the yolk of oviparous ones, as they have milk ready prepared for their firſt nutriment in the breaſt of the mother.

As ſoon as the new foliage of the plant riſing out of the ground becomes expanded, and the root deſcending penetrates the earth with its fibrous ramifications, the umbilical ſyſtems of veſſels ceaſe to act, both the abſorbents, which previouſly ſupplied the young embryon with nutriment from the cotyledons, and alfo the placental artery, which was fpread on the exterior membrane of the cotyledons for the purpofe of oxygenation. Thefe veffels now either coalefce and decay beneath the foil, or wither and fall off, when raifed above it in the form of feed-leaves.

II. 1. The feeds of plants are thus a fexual or amatorial progeny, produced principally by the male part of the flower, and received into a proper nidus, and fupplied with nutriment by the female part of it, and which can thus claim both a father and a mother. But the buds of vegetables are a linear pogeny, produced and nourifhed by a father alone, to whom they adhere, not falling off like the feeds, as is farther treated of in Zoonomia, Vol. I. Sect. XXXIX. II. 2. and in Sect VII. I. 3. of this work. For in this moft fimple kind of vegetable reproduction, by the buds of trees, and by the bulbs of fome plants, and by the wires of others, which are their viviparous progeny, the caudex of the leaf is the parent of the bud or bulb, or wire, which rifes in its bofom, according to the obfervation of Linneus.

This linear or paternal progeny of vegetables in buds or bulbs, or wires, is attended with a very curious circumftance, which is that they exactly refemble their parents, when they are arrived at their maturity, as fhewn in Sect. VII. 1. 3. as is obferved in grafting fruit-trees, and in propagating flower-roots, or ftrawberries, or potatoes, by their wires or roots; whereas the feminal offspring of plants, as it derives its form in part from the mother as well as father, is liable to perpetual variation, both which events are employed to great advantage by fkilful gardeners.

2. As the embryons in the buds are the viviparous offspring of vegetables, it becomes neceffary, as they have no mouths, that they fhould be furnifhed like the embryons in the feeds with umbilical veffels to fupply them with nourifhment, till they acquire roots with another fet of abforbent veffels to imbibe moifture from the earth, and leaves to act like lungs for the purpofe of oxygenating their blood.

Thefe

Thefe umbilical veffels, which fupply the buds of plants with nourifhment in the early fpring, and unfold their foliage, have been much attended to by Dr. Hales and Dr. Walker (Edinb. Phil. Tranfact. Vol. I.) The former obferved, that the fap from the ftump of a vine, which he had cut off in the beginning of April, arofe twenty-one feet high in glafs tubes affixed to it for that purpofe, but which in a few weeks ceafed to bleed. Dr. Walker alfo marked the progrefs of the afcending fap in various branches of trees, and obferved, that in cold weather it ftopped many hours in a day, as well as in the night, and found likewife as foon as the leaves became expanded, that the wounded trees ceafed to bleed.

The veffels, which convey the fap-juice with fuch amazing force, are fituated in or compofe the alburnum, or fap-wood, of the trunk or root of the tree; nor is it furprizing, that fome of it when preffed by fo high a column fhould exfude into the cells between the alburnum and bark, as in thefe cells much fap-juice was obferved by Dr. Walker, and this accounts for the great eafe with which the barks of willows and of oaks are feparated in the fpring from their wood. The abforbent mouths of thefe fap-veffels open externally in the moift earth on the roots of trees, and alfo into the air on their trunks; and thus mix the aqueous fluids, which they thus imbibe, with the faccharine and mucilaginous materials depofited previoufly in the alburnum of thefe roots and trunks.

3. This afcending fap-juice during the fpring feafon is in fome trees fo fweet, that it is ufed in making wine, as that of the birch-tree in this country; and fugar is procured in fuch quantity from a maple in Penfylvania, that from each tree five or fix pounds of good fugar have been made annually without deftroying it. Rufh, on Sugar Maple. Phillips, London. This fugar is depofited I believe in the fap-wood of the trunk and roots of trees, as in the manna-afh, and is diffolved in the fpring by the moifture, which is drank up by the abforbents from the earth and atmofphere, and forcibly carried on to

expand the buds. Its exiſtence in the ſap-wood as well as in the roots is ſhewn from the pullulation of oak-trees, which have been ſtripped of their bark, and alſo from the expanſion of the eyes of a vine-ſhoot, when it is cut from the tree, and planted in the earth, as deſcribed in Sect. XV. 1. 3.

This ſuggeſts to us the reaſon why the wood of trees is ſo much ſooner ſubject to decay, when they are felled in the vernal months; becauſe the ſugar, which the ſap-wood then contains, ſoon runs into fermentation, and produces what is called the dry rot; whence the cuſtom has prevailed of debarking oaks in the ſpring, and felling them in the autumn; and it is probable that the wood of all other trees would laſt much longer, if it was thus managed, as the growth of the new leaves would exhauſt the ſugar of the ſap-wood.

Sweet juices for a ſimilar purpoſe of expanding the buds of herbaceous plants are depoſited during the autumn in their roots, as in turnep, beet, tragapogon; or in the knots or joints of the ſtem, as in graſſes, and the ſugar-cane; which like the farina and oil in ſeeds, and the dulcet mucilage of fruits, and the honey of flowers, were deſigned for the food of the young progeny of plants, but become the ſuſtenance of mankind!

As the ſaccharine matter which is thus depoſited in the roots, or in the alburnum, or in the joints of plants, muſt be diluted by the moiſture abſorbed from the earth by their roots, we underſtand why the leaves of the lower branches of trees are firſt expanded, as is ſeen diſtinctly in the hawthorn hedges in April, as theſe muſt firſt receive the aſcending ſap-juice, as was obſerved by Dr. Walker in his account of the maple.

4. The force of the riſing ſap from a vine-ſtump in the bleeding ſeaſon, as diſcovered by Dr. Hales, is at ſome times equal to the whole preſſure of the atmoſphere, which is about fourteen pounds on a ſquare inch of ſurface. This great power in raiſing the ſap he aſcribes to capillary attraction, and to the variations of heat during the day

day and night. In regard to capillary attraction, however high it may raiſe a fluid in very ſmall tubes, it can not make it flow over them, as the ſap-juice did in Dr. Hales's vine-ſtump ; nor can it raiſe a fluid quite to a level with the upper rim of a glaſs tube, as the fluid is there more attracted downwards by the glaſs beſides its gravity, and is left in conſequence with a concave ſurface.

The means by which vegetable abſorbent veſſels in their living ſtate imbibe the fluids of the earth and atmoſphere, and carry them forwards with ſo much force, muſt be ſimilar to thoſe, with which animal abſorbent veſſels perform the ſame office; that is by their mouths being excited into action by the ſtimulus of the fluids, which they abſorb.

This circumſtance is confirmed by the evident proofs of the irritability of plants in various other inſtances, as the cloſing and opening of the petals and calyxes of flowers by light and darkneſs, warmth and cold, dryneſs and moiſture, and by the motions of the leaves of mimoſa, or ſenſitive plant, and of dionœa muſcipula, by any mechanical ſtimulus. To this might be added a variety of inſtances of the irritability of vegetables to the ſtimulus of heat, being increaſed after a previous expoſure to cold, exactly in the ſame manner as happens to animal bodies, which are enumerated in a note in the Botanic Garden, Vol. I. Canto I. l. 322, whence the reciprocal times of the acting and the ceaſing to act of theſe vernal vegetable abſorbents, which are here termed umbilical veſſels, in the experiments both of Dr. Hales and Dr. Walker, may be readily explained by their having been benumbed by the cold, or excited into action by the warmth of the air or earth. See Sect. XIII. 2. 3.

From one experiment nevertheleſs of Dr. Walker's theſe veſſels occaſionally act as capillary ſyphons, becauſe when he bent down a branch much lower than its origin from the tree, and cut off the end of it in the bleeding ſeaſon, the ſap flowed from the extremity of this branch ſo bent down, when ſome wounds two or three feet lower

lower than the origin of this branch did not bleed. This may be accounted for from the afcent of the fluid in thefe veffels being at this time principally owing to the action of their abforbent mouths, and to their confifting of long cylinders with minute diameters and rigid coats, like thofe which are vifible to the eye in dry cane, through which fmoke will pafs in either direction, and which at this early feafon may not be excited into vegetable action; there is neverthelefs a power of abforption exifting in any part of them in the warmer feafon, becaufe a branch or flower-ftalk cut from the root, and fet in a glafs of water, will drink up a confiderable quantity of it. There is alfo a fituation in their difeafed or dead ftate, where they appear to act for fome years like capillary tubes, as in the decorticated part of a pear-tree, defcribed in Sect. XV. 2, 3.

5. During the great action of thefe umbilical abforbent veffels the buds become expanded, that is the young vegetable beings put forth leaves, which are their lungs, and confift of a pulmonary artery, vein, and abforbents, and alfo acquire a new bark over that of the branches, trunk, and roots, of the laft year, which confifts of aortal arteries, veins, and abforbents, and new radicles, which terminate in the foil. At this time the umbilical veffels, which exifted in the alburnum, or fap-wood, ceafe to act, and coalefce into more folid wood, perhaps fimply by the contraction of the fpiral fibre, of which they are compofed; and the fwarm of new vegetables, which conftitute a tree, are now nourifhed by their proper lacteal and lymphatic fyftems.

A curious circumftance now occurs, which is that wherever a tree is now wounded, no moifture appears. On the contrary, the wound from Dr. Hales's experiments is in a ftrongly abforbing ftate, infomuch that on applying water to wounds made in the fummer feafon, it was found to be drank up with great force, as was ingenioufly fhewn by mercurial fyphons contrived to refift its abforption.

This evinces, that though during the bleeding feafon in the vernal months the fap-juice is imbibed by the umbilical abforbents, and carried

ried upwards probably by the annular contraction of the ſpiral fibres, which I believe compoſe theſe abſorbent veſſels, in ſuch quantities as to bleed wherever the alburnum is expoſed or wounded, yet that afterwards the exhalation by the numerous leaves becomes ſo great, that the actions of the new radical and lateral abſorbents do not ſupply a fluid ſo faſt, as it could otherwiſe be expended in the growth of the plant, or diſſipated into the air; and as the veſſels, which paſs down the trunks of trees, inoſculate in variety of places, as is ſeen in the cloth made at Otaheite from the bark of a mulberry-tree, when a wound is made through ſome of theſe veſſels, the fluid, which might otherwiſe ooze out, is carried away laterally by thoſe in their vicinity; and as the veſſels of vegetables are rigid, and do not collapſe when wounded like thoſe of animals; and as the circulation in them is comparatively ſlow, but little of their contained fluids are poured out of them when wounded in the ſummer months.

6. From all theſe obſervations it finally appears, that the umbilical veſſels of each bud are ſimilar to thoſe of a ſeed, which are called by Dr. Grew ſeminal roots, and that like the umbilical cords, which form the wires of ſtrawberries above ground, and of potatoes under ground, they ſupply the new vegetable with nutriment, till the leaves are expanded in the air, and new roots are puſhed out and penetrate the earth.

There is alſo a curious analogy between theſe umbilical veſſels of buds, which exiſt in the alburnum of trees, and thoſe belonging to the chick in the egg, which conſiſts in their both poſſeſſing certain air-veſſels; thoſe of trees paſs horizontally from the bark to the alburnum, and that of the egg exiſts at the broad end of it. Thus it is probable, that the fluid in the fine extremities of the new veſſels of the embryon bud becomes oxygenated by theſe horizontal air-veſſels, in the ſame manner as the fluid in the terminations of the arteries on the chorion of the chick is believed to become oxygenated by the air

contained

contained at the broad end of the egg, as alluded to in Sect. II. 4. and III. 1. 4.

A circumftance, in which the bud may be conceived to differ from the egg, confifts in the feparation of the egg from its parent, as foon as the fetus has acquired a certain maturity, along with its umbilical veffels, and its refervoir of nutriment. But in vegetables fomething fimilar occurs, for the parent bud is feparated by death in the autumn from its embryon offspring; the leaf falls off, which was the lungs of the parent bud, and the veffels of its caudex, which formed the bark, coalefce into alburnum, or fap-wood, furrounding the umbilical veffels of the new bud; which thus may be faid to loofe its parent like the egg, but retains its umbilical veffels, and a refervoir of nutriment, which exifts in the fap-wood, and alfo another fyftem of veffels, which conftitute the new bark of the tree, confifting of the interwoven caudexes of each individual new bud.

But as the umbilical veffels of plants above defcribed, which conftitute the alburnum of the trunks of trees, and the feminal roots, fo called, of the growing feed, convey nutriment to the embryon bud, or to the rifing plumula, as well as oxygenation, they are not fimilar in that refpect to the placenta of the animal fetus, and were improperly called placental veffels in the notes to the Botanic Garden, as the placenta of the animal fetus is fhewn in Zoonomia, Vol. I. Sect. XXXVIII. to be an organ of refpiration only, like the gills of fifh, and not an organ for nutrition.

Hence when the cotyledons of feeds are cut away from the rifing plume, the plant becomes a dwarf for want of nutriment; and the wounding or expofing the alburnum of bleeding trees, as of the birch or maple, in the vernal months to obtain the fap-juice retards the expanfion of the new buds, and the confequent growth of the tree. Hence alfo it appears, why fmearing the bark of a tree with pitch, or oil, or paint, is liable to deftroy the new buds, and confequently the

5 tree,

tree, by ſtopping up their ſpiracula; and why covering an egg with greaſe or varniſh is ſaid to prevent the production of a chicken, by preventing a change of air at the broad end of it.

7. We may conclude that the umbilical veſſels of the new bud are formed along with a reſervoir of nutritious aliment about midſummer in the bark, which conſtitutes the long caudex of the parent bud, in the ſame manner as a reſervoir of nutritious matter is formed in the root or broad caudex of the turnep or onion, for the nouriſhment of the riſing ſtem. And that theſe umbilical veſſels of the embryon bud, and the reſervoir of nutriment laid up for it, which is ſecreted by the glands of the parent bud, and now intermixed with the preſent bark of the tree, become gradually changed into alburnum, or ſap-wood, as the ſeaſon advances, in part even before the end of ſummer, and entirely during the winter months.

That the alburnum of trees, which exiſts beneath the bark both of the trunk and roots of them, contains the nutritious matter depoſited by the mature leaves or parent buds for the uſe of the embryon buds, appears not only from the ſaccharine liquor, which oozes from the wounds made in the vernal months through the bark into the alburnum of the birch and maple, betula et acer; but alſo from the following experiment, which was conducted in the winter before the vernal ſap-juice riſes.

Part of a branch of an oak-tree in January was cut off, and divided carefully into three parts, the bark, the alburnum, and the heart. Theſe were ſhaved or raſped, and ſeparately boiled for a time in water, and then ſet in a warm room to ferment; and it was ſeen that the decoction of the alburnum or ſap-wood paſſed into rapid fermentation, and became at length acetous, but not either of the other, which evinces the exiſtence both of ſugar and mucilage in the alburnum during the winter months; ſince a modern French chemiſt has ſhewn by experiments, that ſugar alone will not paſs into the vinous fermentation, but that a mixture of mucilage is alſo required; and

 from

from this experiment it may be concluded, that in years of ſcarcity the ſap-wood of thoſe trees, which are not acrid to the taſte, might afford nutriment by the preparation of being raſped to powder, and made into bread by a mixture of flour, or by extracting their ſugar and mucilage by boiling in water, as mentioned in Zoonomia, Part III. Article I. 2. 3. 6.

Now as the embryon buds of deciduous trees of this climate are formed about midſummer, ſecreted by the generative glands in the caudex of the parent leaf-bud, and are ſupplied with due nouriſhment from the ſame ſource, not having yet ſhot out radicles of their own from the lower end of their long caudexes into the earth, they may be readily tranſplanted at this ſeaſon from one tree to another by inoculation, or into different parts of the ſame tree; as the new caudex of the young bud of one tree will readily unite with the new caudex of that of another tree, and as they can be removed entire during the early ſtate of their growth along with a part of the bark only, as ſcarcely any alburnum is yet formed beneath the bark of the young twig, from whence the bud is cut or torn.

But after their greater maturity, ſo that many buds exiſt on one twig, or ſcion, and are already furniſhed with radicles paſſing down into the ground, as in the enſuing ſpring, it becomes neceſſary to ingraft them by cutting off a part of the alburnum, as well as of the bark of the new bud; and to apply theſe in contact with the bark and alburnum of another tree, to which they may grow by inoſculation of veſſels; whence it appears why budding or inoculation muſt be performed ſoon after midſummer, and ingrafting in the early ſpring, as in the former the buds continue to grow by the junction of the caudex or bark veſſels alone with thoſe of the tree into which they are inſerted, and in the latter by the inoſculation of their veſſels with thoſe of the bark and alburnum of the tree, to which they are applied and bound.

The inosculation of the vessels of a bud cut out of one tree and inserted into the bark and alburnum of another, as in the ingraftment of scions, is exactly resembled by a similar operation on animal bodies, when a tooth is taken from one person and inserted into the head of another, and where two inflamed parts grow together. Thus an experienced anatomist is said to have cut the two spurs from a young cock, and applied them to the opposite sides of his comb, which was previously excoriated, where they continued to grow and appeared like horns; and Talicotius, whose book lies by me, seriously asserts, that he succeeded in making artificial noses from a part of the skin of the arm of his patients, and has published prints of the manner of the operation, so ridiculed by the author of Hudibras. Cheirurgia Casparis Talicotii.

The growth of an inoculated bud on the bark of another tree, where the upper part of the caudex of the inoculated bud joins with the lower part of the caudex of another bud belonging to the stock, is still more nicely resembled by the union of the head and tail part of two different polypi in the experiment of Blumenbach, mentioned in Sect. VII. 3. 2. of this work.

8. As the leaves of trees become expanded, the sap-juice above described ceases to flow, and the bark of the tree then adheres to the alburnum. Afterwards from the middle of June to the middle of August, as Dr. Bradley has observed, there seems to be a pause in vegetation; at which time the new buds in the bosom of each leaf seem to be generated, and the bark, which during the two preceding months adhered to the wood, now easily separates, as in the spring, according to the observation of Duhamel, Vol. II. 261; and vegetation, which appeared to languish during the heats of midsummer, acquires new vigour at the approach of autumn like that of spring.

This circumstance, which seems to have puzzled many naturalists, is to be explained from the action of the umbilical vessels of the new

 buds,

buds, which begin to enlarge as ſoon as they are formed, and in this climate have their progreſs ſtopped by the cold during the winter, and the moiſture which exſudes from the ſides of theſe veſſels, and is extravaſated between the alburnum and the bark, cauſes an eaſy ſeparation of them from each other.

From the new flow of ſap in theſe veſſels about midſummer, being probably in part conveyed to the leaves by the rotrograde action of their lymphatics in very hot weather, the honey-dew ſeems to originate either as an exſudation from the leaf, or from the veſſels being punctured by the aphis, which drinks the vegetable chyle in ſuch great quantity that it paſſes through the inſect almoſt unchanged; ſee Sect. XIV. 1. 7. and 3. 2; and thus cauſes the ſuffuſion of honey on the leaves below them for a time in the heat of ſummer.

Add to this that M. Du Hamel, by nicely meaſuring ſome buds, found that they were gradually enlarged at ſome times during the winter, and concludes from thence that the ſap-juice, which nouriſhes them, continues to flow, though ſlowly, in the milder parts of the winter days, Vol. II. p. 262; and adds, that it muſt riſe continually during the winter months in ever-green trees, otherwiſe their foliage would wither; and alſo in deciduous trees, becauſe the branch of an ever-green tree will grow on a deciduous tree, and not loſe its leaves in the winter, as the lauro-ceraſus on a cherry-tree, and an ever-green oak on a common oak.

It muſt nevertheleſs be obſerved, that as the umbilical veſſels are a part of the new bud, as the lacteals and other abſorbents are a part of the chick or fetus, the perpetual action of theſe umbilical veſſels muſt depend on the bud to which they belong, in the caudex of which, between the plumula and radicle, the brain or common ſenſorium, and the conſequent vital energy, are believed to reſide; and that whether an ingraftment exiſts between the bud and the umbilical abſorbent veſſels or not. But as in thoſe animals which have a very

ſmall

ſmall portion of brain in the head compared with that in the ſpine of the back, as in eels, ſnakes, worms, butterflies, if the head be cut off, the other parts will continue to live with great activity for hours, and even days; ſo it happens to theſe umbilical abſorbent veſſels, which in vine-ſtumps, and many herbaceous plants, will continue to pour out the ſap-juice in great force and great quantity for many days after the exſection of the whole upper part of the plant.

The continuance of the motion of theſe umbilical veſſels conſiſting of a ſpiral line, which are believed to be air-veſſels by many authors, is mentioned by Malpighi; who aſſerts, that when he examined them in the winter, he could often obſerve them for ſome time to continue their vermicular motion ſo as to aſtoniſh him. See Duhamel. Phyſ. des arb. Vol. I. p. 43.

9. The umbilical veſſels of this ſection, like the abſorbents of the preceding one, both which are believed to conſiſt of a ſpiral line, as ſhewn in Sect. II. 7. may be readily ſeen in cutting a vine-ſtalk horizontally, as they at firſt appear full of fluid; but in a very little time, as the fluid exhales or becomes effuſed, a circular area of round holes appears to paſs longitudinally interior in reſpect to the bark; which I ſuppoſe to conſiſt both of the umbilical veſſels, which bleed during the vernal months, and of the other radical, cellular, and cutaneous abſorbents; the latter of which I ſuſpect to be exterior to the former, and to reſide between the bark and the umbilical veſſels, though both of them are believed to conſtitute the alburnum of the plant.

From many ingenious obſervations on vegetables monſieur de la Baiſſe draws the following concluſions, which are aſſented to by M. Bonnet, and which I ſhall here tranſcribe, as they ſo accurately coincide with the theory above delivered, and as they were deduced from different experiments, are a confirmation of it. He ſays, "that the veſſels deſtined to convey nouriſhment to plants are neither in the pith, nor in the bark, nor between the bark and the wood;

but

but in the ligneous ſubſtance itſelf; or, to ſpeak more accurately, that thoſe veſſels are themſelves the woody fibres included between the pith and the bark of plants, which have their origin in the roots, and extend themſelves to every part of the plant." Bonnet uſage des feuilles, p. 275.

SECT.

PLATE III.

PLATE III.

Is copied fiom Malpighi Appendix de ovo Incubato, Tom. II. Fig. 54, and repre-fents the chick in the egg on the fourteenth day of incubation. The chick rolled up fwims in the amnios *a a*, which is kept moift by very minute veffels. Round this is placed the yolk *b b*, to which adjoins the thicker part of the white. The whole is fur-rounded with chorion *d d d*. On this are fpread the blood-veffels, of which the large one *e* emerging from the navel of the chick, and generating the various branches *f f f*, terminates in a capillary network. In contact with thefe a redder fet of veffels paffes with fimilar ramifications. Another fet of veffels *g g* arifes from the navel, which are fmaller ones, and are propagated amidft the ramification of *f f*. The lungs are white; the ftomach full of milk, or of coagulated albumen or white; and the inteftines hang out from the navel.

As two fets of blood-veffels terminate on the chorion, and as one branch of the larger fet carries redder blood, and as the lungs are ftill white; it feems evident, that this larger fet of veffels refemble the placental arteries and vein of viviparous animals, and that the blood receives its red colour by acquiring oxygen from the air included between the exter-nal moift membrane and the fhell of the egg; which air at firft is feen only at the broad end, but afterwards extends from thence to the equator of the egg, and probably paffes through the other end of the fhell to that part of the internal membrane, which adheres to it. See an analogous plate in Fabricius ab Aquapendente, Tom. I. Fig. 13. See alfo Sect. III. 1. 4. and III. 2. 6. of this work.

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SECT. IV.

THE PULMONARY ARTERIES AND VEINS OF VEGETABLES.

I. 1. Leaves *not perſpiratory organs, nor excretory nor nutritious organs, nor electric nor luminous ones.* 2. *Vital air in the atmoſphere, in water. Lungs of aerial animals; gills of aquatic ones.* 3. *Leaves are the lungs of vegetables. Arteries and veins viſible in a leaf of ſpurge and picris coloured by madder, and in bloody dock.* 4. *Upper ſurface only of the leaf reſpires, and repels moiſture, and dies if ſmeared with oil, and exhales much leſs than the under one.* II. 1. Aquatic leaves *are like the gills of fiſh; have larger ſurfaces, as the uncombined oxygen in water is leſs than in air; are divided like the leaves on high mountains.* 2. *Are furniſhed with numerous points like gills of fiſh.* 3. *Which ſet at liberty oxygen from ſome waters.* III. 1. Root-leaves *of many plants differ from ſtem-leaves.* 2. *As they produce only buds.* 3. *They differ as common leaves from floral leaves.* 4. *And ariſe ſometimes from the cotyledons.* IV. 1. Floral leaves *or bractes are reſpiratory organs to the calyx and pericarp.* 2. *In ſome plants they do not appear till the corol drops off.* 3. *Recapitulation. Leaves die in the exhauſted receiver.* V. 1. The corol *is a pulmonary organ; its colours.* 2. *Its vaſcular texture, its glands. Some flowers have no bractes. The corol is not for defence. The corol of helleborus niger changes to a calyx.* 3. *Corol of colchicum and crocus fall off before the bractes appear. Vines bear alternate flowers and leaves. Fruit deprived of green leaves.* 4. *Vegetable uterus requires the bractes. Flowers enlarged by deſtroying the green leaves.* 5. *Plants do not reſpire in their ſleep.* 6. *Concluſion. The anthers and ſtigmas are ſeparate vegetable beings; live on honey and acquire greater irritability, and amatorial ſenſibility.*

I. 1. There have been various opinions concerning the uſe of the leaves of plants in the vegetable economy. Some have contended, that they are perſpiratory organs. This does not appear probable from an experiment of Dr. Hales, Veg. Stat. p. 30. He found, by cutting off branches

branches of trees with apples on them, and taking off the leaves, that an apple exhaled about as much as two leaves, the furfaces of which were nearly equal to that of the apple ; whence it would appear, that apples have as good a claim to be termed perfpiratory organs as leaves.

Others have believed them the excretory organs of excrementitious juices ; but as the vapour exhaled from vegetables has no tafte, this idea is no more probable than the other. Add to this, that in moift weather they do not appear to perfpire or exhale at all, as fhewn by fome ftatical experiments of Dr. Hales, like thofe of Sanctorius on the perfpiration of the human body ; which perfpiration has alfo been fuppofed to be an excrement, which is fhewn to be an erroneous opinion ; and that its defign is fimply to preferve the fkin fupple, like the tears diffufed on the eye-ball to preferve its tranfparency, as explained in Zoonomia, Vol. II. Clafs I. 1, 2. 14.

Others have believed that vegetables abforb much nutriment by their leaves, and quote an experiment of Dr. Prieftley's, who found plants placed in water under glaffes grew much fafter, when the air, in which they grew, was occafionally impregnated with putrid exhalations. But there is another experiment of Dr. Prieftley's, which fhould be mentioned, and that is, that he agitated one part of a veffel of water beneath a glafs filled with putrid exhalation, and the whole of the water prefently became very fetid. Hence we may conclude, that in the firft cafe the water, in which the vegetable grew, abforbed the putrid exhalations from the air over it, and that thefe were again abforbed from the water by the roots of vegetables, which correfpond to the lacteals of the ftomach and inteftines of animals ; and that they thus received nourifhment from the putrid vapours, and not by their leaves, which we fhall endeavour to fhew to be fimply refpiratory organs.

Other philofophers have conceived, that the leaves of plants acquire electricity from the air. In anfwer to thefe it may be obferved, that no no electricity is ſhewn by experiments to deſcend through the ſtems of trees, except in thunder ſtorms; and that if the final cauſe of vegetable leaves had been to conduct electricity from the air, they ought to have been gilded leaves with metallic ſtems.

Others again have ſuppoſed that the leaves of plants acquire a phlogiſtic material from the ſun's light, whence it was believed that on this account they turn their upper ſurfaces to the ſun. But though light is more or leſs attracted by all opake bodies, yet if the final cauſe of vegetable leaves had been to abſorb light, they ought to have been black and not green; as by Dr. Franklin's experiment, who laid ſhreds of various colours on ſnow in the ſun-ſhine, the black ſunk much deeper than any other colour, and conſequently abſorbed much more light. The uſe of light in vegetable reſpiration will be treated of in Sect. XIII.

2. The air of our atmoſphere has been ſhewn by the experiments of Prieſtley, Cavendiſh, and Lavoiſier, to conſiſt of twenty-ſeven parts of reſpirable air, called oxygene gas, with ſeventy-three parts of unreſpirable air, termed azotic gas, which are mixed together, not chemically combined; whereas water conſiſts of eighty-five hundreth parts of oxygen to fifteen of hydrogen, which exiſt in their ſtate of combination, and are not therefore fit for reſpiration. But in water a conſiderable quantity of common air is alſo diſſolved, which eſcapes on boiling; and even pure vital air was diſcovered in the water of ſome ſprings by ſir Benj. Thomſon, when it was expoſed to the ſun's light. Philoſoph. Tranſact. The former of theſe fluids is thus adapted to the reſpiration of aerial animals, and the latter to that of aquatic ones; and the analogy between the aerial and aquatic leaves of vegetables and the lungs and gills of animals embraces ſo many circumſtances, that we can ſcarcely withhold our aſſent to their performing ſimilar offices.

The internal ſurface of the air-veſſels of the lungs of men are ſaid to be equal to the external ſurface of the whole body, or about fifteen ſquare feet. On this ſurface the blood is expoſed to the influence of the reſpired air, through the medium of a thin moiſt pellicle. By this expoſure to the air it has its colour changed from deep red to bright ſcarlet, and acquires ſomething ſo neceſſary to the exiſtence of life, that we can live ſcarcely a minute without this wonderful proceſs.

In aquatic animals, as fiſh, the blood is expoſed to the air, which is diffuſed in the water by the gills; the ſurface of which is probably greater in proportion to the external ſurface of their bodies, than that of the air-veſſels of the lungs of aerial animals to their external ſurfaces. Through theſe gills, or aquatic lungs, a current of water is made perpetually to paſs by the gaping of the fiſh, as it moves, like the air in reſpiration; and from this water it is probable the ſame material is acquired by the gills of fiſh as from the air by the lungs of aerial animals.

3. The great ſurface of the leaves compared to that of the trunk and branches of trees is ſuch, that it would ſeem to be an organ well adapted for the purpoſe of expoſing the vegetable juices to the influence of the air. This however we ſhall ſee afterwards is probably performed only by their upper ſurfaces, which are expoſed to the light as well as air, and on that account acquire greater oxygenation, as will be ſhewn hereafter: yet even in this caſe the upper ſurfaces of the leaves muſt bear a greater proportion to the ſurface of the bark of the tree than that of the air-cells of the lungs of animals to their external ſurfaces.

Aerial or aquatic animals, by their muſcular exertions, produce a current of air or water reciprocally to and from their lungs, and can occaſionally change the place, where they reſpire, when the air or water becomes vitiated. But as vegetables have but little muſcular power to move their leaves, except in a few inſtances; and as the air or water is frequently nearly ſtationary, where they exiſt, it ſeems to have been neceſſary to expoſe their fluids to the air or water on a greater

greater expanſe of ſurface than in the lungs or gills of animals, which well accounts for the exuberant extent of their foliage.

In the lungs of animals the blood, after having been expoſed to the air in the extremities of the pulmonary artery, is changed in colour from deep red to bright ſcarlet, and is then collected and returned by the pulmonary vein. So in the leaves of plants the vegetable blood is rendered yellow in ſome plants, as in celandine, chelidonium; white in others, as in fig-leaves, ficus; and in ſpurge, euphorbia; and red in others, as in red beets, beta. And the ſtructure of the leaf, as conſiſting of arteries and veins to expoſe the vegetable blood to the influence of the air, and to return it to the caudex of the bud at the foot-ſtalk of the leaf, beautifully became viſible by the following experiment.

A ſtalk with the leaves and ſeed-veſſels of large ſpurge (euphorbia helioſcopia) in June 1791, had been ſeveral days placed in a decoction of madder, (rubia tinctoria) ſo that the lower part of the ſtem and two of the inferior leaves were immerſed in it. After having waſhed the immerſed leaves in much clean water, I could readily diſcern the colour of the madder paſſing along the middle rib of each leaf. This red artery was beautifully viſible both in the under and upper ſurface of the leaf; but on the upper ſide many red branches were ſeen going from it to the extremities of the leaf, which on the other ſide were not viſible except by looking through it againſt the light. On this under ſide a ſyſtem of branching veſſels carrying a pale milky fluid, were ſeen coming from the extremities of the leaf, and covering the whole underſide of it, and joining into two large veins, one on each ſide of the red artery in the middle rib of the leaf, and along with it deſcending to the foot-ſtalk or petiole. On ſlitting one of theſe leaves with ſciſſars, and having a common magnifying lens ready, the milky blood was ſeen oozing out of the returning vein on each ſide of the red artery in the middle rib, but none of the red fluid from the artery.

All theſe appearances were more eaſily ſeen in a leaf of picris treated in the ſame manner; for in this milky plant the ſtems and middle-rib of the leaves are ſometimes naturally coloured reddiſh, and hence the colour of the madder ſeemed to paſs further into the ramifications of their leaf-arteries, and was there beautifully viſible with the returning branches of milky veins on each ſide.

In a plant which was ſent to me under the name of ſenecio bicolor, but which I have not yet ſeen in flower, the upper ſurface of the leaf is green like moſt other leaves, but during the vernal months the under ſurface is of a deep red, whence I conclude that the vegetable blood acquires the red colour in the terminations of the pulmonary artery in the upper ſurfaces of the leaves, which becomes viſible as it paſſes in the large veins on the inferior ſurface. In the ſame manner the red colour of the blood is moſt viſible in the large veins beneath the leaf of the red veined dock, rumex ſanguinea.

4. From theſe experiments the upper ſurface of the leaf appeared to be the immediate organ of reſpiration, becauſe the coloured fluid was carried to the extremities of the leaf by veſſels moſt conſpicuous on the upper ſurface, and there changed into a milky fluid, which is the blood of the plant, and then returned by concomitant veins on the under ſurface, which were ſeen to ooze when divided with ſciſſars, and which in picris particularly rendered the under ſurface of the leaves greatly whiter than the upper one.

As the upper ſurface of leaves conſtitutes the organ of reſpiration, on which the vegetable blood is expoſed in the terminations of arteries beneath a thin moiſt pellicle to the action of the atmoſphere, theſe ſurfaces in many plants ſtrongly repel moiſture, as cabbage-leaves, whence the particles of rain lying over their ſurfaces without touching them, as obſerved by Mr. Melville, (Eſſays Literary and Philoſ. Edinb.) have the appearance of globules of quick-ſilver. And hence leaves laid with their upper ſurfaces on water wither as ſoon as in the dry air, but continue green many days if placed with their under ſurfaces on water,

water, as appears in the experiment of monſieur Bonnet, (Uſage des Fevilles); hence ſome aquatic plants, as the water-lily (nymphæa) have the lower ſides of their leaves floating on the water, while the upper ſurfaces remain dry in the air.

This repulſion of the upper ſurfaces of the leaves of aerial plants to water bears ſome analogy to the renitency of the larinx to the admiſſion of water into the lungs of animals; for if a ſingle drop accidentally falls into the windpipe, a convulſive cough is induced till it is regurgitated. For the ſame reaſon ſeveral plants cloſe together the upper ſurfaces of their leaves when it rains, in the ſame manner as in their ſleep during the night, as mimoſa, the ſenſitive plant, and the young ſhoots of chick-weed, alſine; and of kidney-bean, phaſeolus.

As thoſe inſects which have many ſpiracula, or breathing apertures, as waſps and flies, are immediately ſuffocated by pouring oil upon them, in the year 1783 I carefully covered with oil the ſurfaces of ſeveral leaves of phlomis, of Portugal laurel, and balſams; and though it would not regularly adhere, I found them all die in a day or two, which ſhews another ſimilitude between the lungs of animals and the leaves of vegetables.

There is an ingenious experiment of M. Bonnet, (Uſage des feuilles) which ſhews that the upper ſurfaces of leaves exhale much leſs than their under ſurfaces. He put the ſtalks of many leaves freſh plucked from trees or herbaceous plants into glaſs tubes filled with water; of theſe he covered with oil or varniſh the upper ſurface of many leaves, and the under ſurface of many others, and uniformly obſerved by the water ſinking in the tubes that the upper ſurfaces exhaled much leſs than half the quantity exhaled by the under ſurfaces, which ſhews them to be organs deſigned for different purpoſes.

II. 1. There exiſts a ſtrict analogy between the leaves of aquatic plants, which are conſtantly immerſed beneath the water, and the gills of aquatic animals, which confifts in the largenefs of their furface, owing to their hair-like fubdivifions, and to their being terminated with innumerable points. The gills of fifh confift of many folds of blood-veffels lying over each other, each refembling a fringe, or the downy part on one fide of a feather attached to the middle rib of it, by which means they expofe a greater furface of blood to the water than is expofed to the air by the internal membranes of the air-cells of the lungs of other animals; and undoubtedly for this final caufe, becaufe water contains lefs oxygen in its uncombined ftate, which is the material neceffary to life, than air, though much more of it in its combined ftate, as water confifts of eighty-five parts of oxygen to fifteen parts of hydrogen; but it is the uncombined oxygen only diffolved in heat, and diffufed in water, which can ferve the purpofe of animal or vegetable refpiration.

The apparatus for this purpofe, according to Duverney's Anatomy of a Carp, is truly curious. He found 4386 bones in the gills, which had fixty-nine mufcles to give them their due motions. See Bomare's Dictionaire raifoneé, Art Poiffon. And Monro obferved by the numerous divifions and folds of the membrane of the gills, that their furface in a large fkate was nearly equal to the furface of the human body. Phyfiol. of Fifh, p. 15. He adds that in the whole gills there exift 144,000 fubdivifions or folds, and that the whole extent of this membrane may be feen by a microfcope to be covered with a network of exceedingly minute veffels.

2. In this refpect the gills of fifh are refembled by the fubaquatic leaves of plants, which are flit into long wires terminated in points, as in trapa, œnanthe, hottonia, the water-violet, and the water-ranunculus. This laft plant, and fome others, have frequently fome leaves erect in the air, and others immerfed in water, arifing from the fame ftem; and it is curious to obferve that the aerial leaves are nearly entire, or divided only into a few lobes; whilft the aquatic leaves are flit into innumerable branches like a fringe, and have thus

their ſurfaces wonderfully enlarged for the purpoſe of acquiring uncombined oxygen from the air, which is diffuſed in the water, and which abounds ſo much leſs there than in the atmoſphere; for the ſame purpoſe the plants on the ſummits of high mountains, where the air is ſo much rarer, and conſequently abounds leſs with oxygen, have their leaves much more divided than in the plains, as pimpinella, petroſelinum, and others, that they may expoſe a more extenſive ſurface of veſſels to the influence of the thinner atmoſphere.

3. This great enlargement of the ſurface by ſo minute a diviſion does not however ſeem to be the only uſe of this uniform ſtructure of gills and aquatic leaves; but there is another very important one, which hath hitherto I believe eſcaped the notice of philoſophers; and that is that points and edges contribute much to the ſeparation of the air, which is mechanically mixed or chemically diſſolved in water, as appears on immerſing a dry hairy leaf into water freſh from a pump, on which innumerable globules of air, like quick-ſilver, appear on almoſt every point. Nor is it improbable that points immerſed in water may in a bright day contribute to decompoſe it, or certainly to ſet at liberty its ſuperabundant oxygene, as occurs in the perſpiration of leaves when expoſed to the ſunſhine, and to the green matter in the experiments of Dr. Prieſtley, which is probably owing to the fine points of both of them; and laſtly, when points of ſilk are immerſed in ſpring water, which is frequently hyperoxygenated, as in the experiments of Count Rumford, related in the Philoſ. Tranſact. See Sect. XIII. I. 5.

III. 1. The *root-leaves* of many perennial plants, which do not produce flowers in the firſt year from the ſeed, are different from thoſe of future years, as in the rheum palmatum, palmated rhubarb, the leaves are ſmall and nearly circular, and not divided into fingers till the ſecond year; and in tulip the leaf the firſt year from the ſeed is ſmall like a blade of graſs, riſing from a diminutive bulb. In other perennial plants the root-leaf is undivided, but at the ſame time larger than

than thofe on the rifing ftem, as in geum, averns; in fenecio aureus, and the campanula rotundifolia, fo named from the round form of the root-leaf, which is alfo much broader than thofe on the ftem, as well as undivided. The root-leaves of many biennial, and of fome annual plants, are likewife larger, as well as of a different form from thofe on the rifing flower-ftem, as in turneps and carrots. And laftly, the root-leaves of fome plants, which rife immediately from feeds, confift of the cotyledons of the feed, and are thus different from the leaves above them.

2. In refpect to the root-leaves of palmated rhubarb and of tulips, when thefe plants are raifed immediately from feed, as thefe firft plants are not defigned to generate flowers and confequent feeds, but to produce fimply another plant like a leaf-bud of a tree, lefs oxygenation feems to have been neceffary, and the leaves therefore require lefs furface, and are in confequence undivided. In refpect to the root-leaves of geum, and of campanula rotundifolia, which are larger than their ftem-leaves, it is probable that they lay up a refervoir of nutritious matter for the rifing ftem, like thofe of turneps and carrots, and thus require greater oxygenation, and in confequence a greater furface.

3. Another difference of root-leaves from thofe of the ftem in annual plants often confifts in the latter being properly bractes or floral-leaves, which will be fpoken of below, while the root-leaf refembles thofe belonging to the leaf-buds of trees. Thus in the rifing ftem of wheat the root-leaf produces the firft joint above the foil, and the fecond and third leaf produce joint above joint, which are each a feparate bud rifing on that below it, as is feen by the divifion of the pith or hollow part of one joint from another, and at length the uppermoft leaf is a bracte or floral-leaf belonging to the ear.

4. And laftly, the feed-leaves which rife out of the ground with the firft joint of the flower-ftem, as in kidney-bean, phafeolus, as they confift of the placental artery, which was fpread on the cotyle-

dons

dons of the ſeed, and, now riſing out of the earth, when the nutritive part has been diſſolved in the terrein moiſture and abſorbed, they ſerve the office of an aerial pulmonary organ, or lungs, which before ſerved that of an aquatic one, or gills; but wither and fall off as the true leaves become expanded.

IV. 1. The common foliage of deciduous plants conſtitutes the organ of reſpiration already ſpoken of, which belongs to the leaf-buds during the ſummer months, and drops off in the autumn, when thoſe buds periſh by the cold, or by the natural termination of their exiſtence. But there is another kind of foliage diſſimilar to the former, conſiſting of bractes or floral-leaves, which ſupply an organ of reſpiration to the calyx and pericarp of the flower-bud. Theſe frequently differ in ſize, form, and colour from the other leaves of the plant, and are ſituated on the flower-ſtalk often ſo near the fructification as to be confounded with the calyx. In ſome plants there are two ſets of floral-leaves, or bractes, one at the foot of the umbel, and another beneath each diſtinct floret of it; and in others they appear in a tuft above the flower, as well as on the ſtalk beneath it, as in fritillaria imperialis, crown imperial; and in others they are ſo ſmall as to be termed ſtipulæ or props.

All theſe kinds of bractes, or floral-leaves, ſerve the office of lungs for the purpoſe of expoſing the vegetable blood to the influence of the air, and of preparing it for the ſecretion, or production and nouriſhment of the vegetable uterus, or pericarp, and of the ſeeds produced and retained in it, frequently before their impregnation, and always after it.

2. It muſt be obſerved that in many plants theſe floral-leaves, or bractes, do not appear till after the corol and nectaries, with the anthers and ſtigmas, drop off; that is, not till after the ſeed is impregnated, as in colchicum autumnale, crocus, hamamelis, and in ſome fruit-trees. The production of the vegetable uterus, or pericarp, with the unimpregnated ſeeds included in it, is in theſe plants accompliſhed or

 evolved,

evolved, like the bractes themſelves with the corol and ſexual organs, by the ſap-juice, forced up in the umbilical veſſels from ſome previouſly prepared reſervoir, without the neceſſity of any expoſition to the air in leaves or lungs, which are not yet formed, though it may acquire oxygenation in the fine arteries of the embryon buds, which are ſuppoſed to ſurround the horizontal air-veſſels obſerved in the bark of trees.

As ſoon as the ſeeds become impregnated, the corol and nectaries with the ſexual organs fall off, and the pericarp and its contained ſeeds are then nouriſhed by the blood, which is aerated or oxygenated in the bractes, or floral-leaves. Thus the flower of the colchicum appears in autumn without any green leaves, and the pericarp with its impregnated ſeeds riſes out of the ground in the enſuing ſpring on a ſtem ſurrounded with bractes, and with other green leaves below them, which produce new bulbs in their boſoms.

The blood, which thus ſupplies nutriment to the pericarp and its included ſeeds, does not ſeem to require ſo much oxygenation as that which ſupplies nutriment to the embryon buds; whence the floral leaves are in general much leſs than the root-leaves in many plants, and than the common green leaves of almoſt all vegetables. And in the plant mentioned in No. I. 3. of this ſection, under the name of ſenecio bicolor, the under ſurfaces of the ſtem-leaves near the expected flower ceaſed to be red like thoſe of the radical leaves, which ſeemed to ſhew that the vegetable blood was in them leſs oxygenated.

Whence it may be believed that leſs irritability may be neceſſary for the growth of the ſeed than of the embryon bud, as the former does not yet perhaps poſſeſs ſo much vegetable life as the latter. And laſtly, that as the anthers and ſtigma require greater irritability, and ſome ſenſibility, it was neceſſary a ſecond time to oxygenate the blood which ſupplies them with nutriment in the corols of the flowers. See Sect. VII. 2. 4.

3. Recapitulation of the arguments tending to ſhew that the leaves of

of vegetables are their lungs. 1. They confift of an artery, which carries the fap to the extreme furface of the upper fide of the leaf, and there expofes it under a thin moift pellicle to the action of the air; and of veins, which there collect and return it to the foot-ftalk of the leaf, like the pulmonary fyftem of animals. 2. In this organ the pellucid fap is changed to a coloured blood, like the chyle in paffing through the lungs of animals. 3. The leaves of aquatic plants are furnifhed with a larger furface, and with points like the gills of aquatic animals. 4. The upper fides of aerial leaves repel moifture, like the larynx of animals. 5. Leaves are killed by fmearing them with oil, which in the fame manner deftroys infects by ftopping their fpiracula, or the air-holes to their lungs. 6. Leaves have mufcles appropriated to turn them to the light, which is neceffary to their refpiration, as will be fhewn in the Section on Light. 7. To this may be added an experiment of Mr. Papin related by M. Duhamel. He put an intire plant into the exhaufted receiver of an air-pump, and it foon perifhed; but on keeping the whole plant in this vacuum except the leaves, which were expofed to the air, it continued to live a long time, which he adds is a proof that the leaves are the organs of refpiration. Phyfic des arbres, V. I. p. 169.

V. 1. The organs of refpiration already defcribed confift of the green leaves belonging to leaf-buds, and of the bractes belonging to flower-buds. But there is another pulmonary fyftem totally independent of the green foliage, which belongs to the fexual or amatorial parts of the fructification only, I mean the corol or petals. In this there is an artery belonging to each petal, which conveys the vegetable blood to its extremities, expofing it to the light and air under a delicate moift membrane covering the internal furface of the petal, where it often changes its colour, as is beautifully feen in fome party-coloured poppies, though it is probable that fome of the irridefcent colours of flowers may be owing to the different degrees of tenuity of the exterior membrane of the petal refracting the light like ſoap-bubbles.

The vegetable blood is then collected at the extremities of the corol-arteries, and returned by correſpondent veins exactly as in the green foliage, for the ſuſtenance of the anthers and ſtigmas, and for the important ſecretions of honey, wax, eſſential oil, and the prolific duſt of the anthers, and thus conſtitutes a pulmonary organ, as is ſhewn by the following analogies.

2. Firſt, the vaſcular ſtructure of the corol, as above deſcribed, and which is viſible to the naked eye; and its expoſing the vegetable juices to the air and light during the day evinces that it is a pulmonary organ.

Secondly, as the glands which produce the prolific duſt of the anthers, the honey, wax, and frequently ſome odiriferous eſſential oil, are generally attached to the corol, and always fall off and periſh with it, it is evident that the blood is elaborated or oxygenated in this pulmonary ſyſtem for the purpoſe of theſe important ſecretions.

Thirdly, many flowers, as the colchicum and hamamelis, ariſe naked in autumn, no green leaves appearing till the enſuing ſpring; and many others put forth their flowers, and complete their impregnation early in the ſpring, before the green foliage or bractes appear, as mezereon, and ſome fruit-trees, which ſhews that theſe corols are the lungs belonging to theſe parts of the fructification.

Fourthly, this organ does not ſeem to have been neceſſary for the defence of the ſtamens and piſtils, ſince the calyx of many flowers, as tragopogon, performs this office; and in many flowers theſe petals themſelves are ſo tender as to require being ſhut up in the calyx during the night. For what other uſe then can ſuch an apparatus of veſſels be deſigned?

Fifthly, in the helleborus niger, Chriſtmas-roſe, after the ſeeds are grown to a certain ſize, the nectaries, and ſtamens, and ſtigmas, drop off,

off, and the beautiful large white petals change their colour to a deep green, and gradually thus become a calyx, inclofing and defending the ripening feeds; hence it would feem that the white veffels of the corol ferved the office of expofing the blood to the action of the air, for the purpofes of feparating or producing the honey, wax, and prolific duft; and when thefe were no longer wanted, that thefe veffels coalefced, like the umbilical veffels of animals after their birth, and thus ceafed to perform that office, and loft at the fame time their white colour. Why fhould they lofe their white colour unlefs they at the fame time loft fome other property befides that of defending the feed-veffel, which they ftill continue to defend?

Sixthly, neither the common green leaves nor the bractes are neceffary to the progrefs of the corol, and ftamens, and ftigma, or to the fecretion of honey, after the laft year's leaves are fallen off, as is evinced by the flowers of colchicum in the autumn, and of crocus in the fpring, in both which the feeds rife out of the earth with their common leaves and bractes fo long after the difappearance of the flower. In deciduous plants the common green leaves ferve as lungs in the fummer and autumn to each individual bud, which then produces the new buds in its bofom, which are either leaf-buds or flower-buds. In the enfuing fpring the new common leaves are the refpiratory organ belonging to the leaf-buds, and the bractes are the refpiratory organ to the pericarp, and its included feeds before or after impregnation; and the corols, as foon as expanded, become the lungs to the amatorial parts of the fructification, and require neither the green leaves nor bractes.

3. Hence the vine bears fruit at one joint without leaves, and leaves at the other joint without fruit. Hence the flower of the colchicum rifes out of the ground without bractes or other green leaves, and flourifhes till the feed is impregnated; and the bractes, which rife out of the ground on the ftem in the following fpring, are lungs to give maturity to the pericarp and feed; and the other green leaves are

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for the purpofe of producing new bulbs round the old one, but can have nothing to do with the corol, anthers, ftigmas, and nectaries, which have long fince fallen off, and perifhed. And laftly, when currant or goofeberry trees lofe their common green leaves, and their bractes, by the depredation of infects; the new leaf-buds become fmall and weak, but the corol, anthers, ftigmas, and nectaries, continue to flourifh, and the fruit becomes impregnated, though it is lefs fweet and of lefs fize from the pericarp and included feed wanting their due nutrition by the bractes before or after impregnation.

4. It hence appears that the flower-bud, after the corol, ftamens, ftigmas, and nectaries fall off, becomes fimply a vegetable uterus, for the purpofe of fupplying the growing embryons with nourifhment, and poffeffes a fyftem of abforbent veffels, which brings the fap-juice to the foot-ftalk of the fruit, and which there changes into a pulmonary artery, which conftitutes the bractes or floral-leaves, and expofes the acquired juices to the oxygenation of the air, and converts them into vegetable blood. This blood is collected again by the veins of the bractes, and conveyed by an adapted or aortal artery for the various fecretions of faccharine, farinaceous, or acefcent materials, for the nourifhment of its included embryons, or the conftruction of the fruit and feed-lobes.

At the fame time, as perhaps all the veffels of trees inofculate, the fruit may become fweeter and larger when the green leaves as well as the bractes continue on the tree; but the corols with the ftamens, ftigmas, and nectaries, (the fucceeding fruit not confidered) fuffer, I believe, no injury, when the green-leaves and even the bractes are taken off, as by the depredations of infects. Some florifts have obferved this circumftance, and affirm that in many plants when the leaves are pulled off, the flowers become ftronger from their then producing no bulbs, as in tulips and hyacinths. The inofculation of vegetable veffels is evinced by the increafed growth of one bud, when others in its vicinity are cut away.

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5. The ſleep of plants has been much ſpoken of by Linneus and others, but there is a wonderful circumſtance occurs in it, which has not been noticed; which is, that it ſeems to reſemble the torpor of winter-ſleeping inſects and other animals, as many plants do not appear to reſpire during this part of their exiſtence; for ſome vegetables cloſe together the upper ſurfaces of their leaves, both during their ſleep and in rainy weather, as mimoſa, ſenſitive-plant; phaſeolus, kidney-bean; and the terminal ſhoots of alſine, chickweed. Many other plants cloſe their petals and calyxes during their ſleep as well as in rain, as convolvulus; and ſome even in the bright daylight, as tragapogon; and yet all theſe plants are believed by gardeners to grow, when young, faſter in the night.

We muſt obſerve, that this ſleep of plants, though it may reſemble the torpor of winter-ſleeping animals, is not to be confounded with the ſtate of deciduous plants in the winter, as that conſiſts in the death of the laſt year's bud, and the embryon condition of the new buds. It would hence appear, that perpetual reſpiration is leſs neceſſary to the vegetable than to the animal world; and that as leſs is waſted during the inactive ſtate of ſleep, it is poſſible that young plants may increaſe in weight, or grow faſter, during this ſtate of inactivity, as animals are obſerved to reſpire leſs frequently during their ſleep, and yet are believed when young to grow faſter during their hours of reſt than of exerciſe. So both in the experiments of Dr. Hales and Dr. Walker on plants during the bleeding ſeaſon, the aſcent of the ſap-juice not only ſtopped during the night, but ſometimes became retrograde, which might nevertheleſs be aſcribed to the torpor of the abſorbent ſyſtem induced by cold, as well as to that of ſleep.

6. We may draw this general reſult, that the common leaves of trees are the lungs of the individual vegetable beings, which form during the ſummer new buds in their boſoms, whether leaf-buds or flower-buds, and which in reſpect to the deciduous trees of this climate

mate perifh in autumn ; while the new buds remain to expand in the enfuing fpring. Secondly, that the bractes, or floral-leaves, are the lungs of the pericarp or uterus, and to the growing feeds which it contains, as the bractes on the ftem of the crown-imperial, fritillaria imperialis, and the tuft above its flowers. And thirdly, that the corol or petals are the lungs belonging to the anthers and ftigmas, which are the fexual or amatorial parts of the plant, and to the nectaries for the fecretion of honey, and to the other glands which affords effential oil and wax.

Laftly, the ftamina and ftigma with the petals and nectary, which conftitute the vegetable males, and the amatorial part of the female, as they in fome plants appear before the green leaves or bractes, as in colchicum and mezereon, and in all plants fall off when the female uterus is impregnated, would appear to be diftinct beings, totally different both from the leaf-buds, which produce a viviparous progeny ; and alfo from the bractes with the calyx and pericarp, which conftitute the vegetable uterus.

They muft at firft receive nutriment from the vernal fap-juice, like the expanding foliage of the leaf-buds, or the bractes of the flower-buds. But when the corol becomes expanded, and conftitutes a new pulmonary organ, the vegetable juices are expofed to the air in the extremities of its fine arteries beneath a moift pellicle for the purpofe of greater oxygenation, and for the important fecretion of honey; and then the anthers and ftigmas are fupplied with this more nutritious food, which they abforb from its receptacle, the nectary, after it has there been expofed to the air, and are thus furnifhed with greater irritability, and with the neceffary amatorial fenfibility, and live like bees and butterflies on that nutritious fluid. See Sect. VII. II. 4.

SECT.

SECT. V.

THE AORTAL ARTERIES AND VEINS OF VEGETABLES.

1. Aortal arteries in vegetables have correfpondent veins. Shewn by experiment on picris, tragopogon, and euphorbia. Seen in the calyx of flowers. Circulation fhewn by ingrafting ftriped-paffion-flower, and jafmine, and hardier fcions on cankered ftems, from fruit-grafts on bad ftocks degenerating. 2. Vegetable circulation performed without a heart, as in the aorta and liver of fifh. 3. Force of the mouths of abforbents greater than that of the heart in producing circulation. Why there is no pulfation in the vena portarum. Circulation in the veins of animals produced by abforption. Very fmall refiftance in the capillaries and glands. Wounds in trees ftrongly abforb fluids except in the bleeding feafon. 4. Vegetable veffels too minute to carry red blood, hence not eafily injected with coloured fluids. Charcoal injected with quickfilver, or melted wax. 5. Recapitulation. Circulation performed by irritability of the veffels, and by the great power of abforption, and the action of the fides of veffels confifting of a fpiral line. 6. Veffels unite at the lower and upper caudex gemmæ. Abforbents and umbilical veffels confift of a fpiral line. Experiment by placing euphorbium firft in a decoction of galls, and then in a folution of green vitriol. Junction of great vein, abforbent trunk, and pulmonary artery in the upper caudex gemmæ. Embryon bud feen in contact with the pith. Experiments with charcoal injected with white paint, fuet, wax, and quickfilver.

1. THE two principal arteries in animal bodies are the pulmonary artery and the aorta. The former receives the blood from the right cavity of the heart, and difperfing it round all the air-cells which terminate the bronchia, or air-pipes of the lungs, expofes it to the influence of the atmofphere through the thin moift membrane, which lines them. This we have fhewn in Sect IV. I. 3. to be refembled in its office by the vegetable arteries, which carry their blood up the

foot-ſtalks of the leaves, and expoſe it on the upper ſurface of them to the influence of the air through a thin moiſt pellicle, where it changes its colour, and returns by correſpondent veins like the blood of animals.

The aortal arteries of the more perfect animals receive the blood from the left cavity of the heart, after it has been expoſed to the influence of the air in the lungs, and diſperſe it by numerous ramifications over the whole body for the purpoſes of ſecretion and nutrition. In leſs perfect animals the aorta itſelf has a pulſation, and carries forward the blood without the aſſiſtance of a heart, as may be ſeen in the back of a full-grown ſilk-worm by the naked eye, and very diſtinctly by the uſe of a common lens. After the blood has paſſed the various glands and capillaries, it is received by another ſyſtem of veſſels, the veins, which conſtitute a kind of reſervoir for the quantity of blood, that remains unexpended by the ſecretions, excretions, nutrition, and growth of the animal; by theſe it is again carried to the right cavity of the heart, and again expoſed in the lungs to the influence of the air.

In a ſimilar manner the branching veins, which bring the blood from the leaves of plants, after it has been expoſed to the influence of the air, unite at the foot-ſtalk of each leaf into more or fewer trunks, as may be ſeen in tearing off the foot-ſtalk of a leaf of a cheſnut-tree from the ſtem; and there without the interpoſition of a heart, like the circulation in the aorta of fiſh, and that in the livers of red-blooded animals, theſe venous trunks take the office of arteries, and diſperſe the blood downwards along the bark to the roots, and to every other part of the vegetable ſyſtem, performing the various purpoſes of ſecretion, excretion, and nutrition, as was ſhewn in the experiment of placing a fig-leaf in a decoction of madder, deſcribed in Sect. IV. 1. 3. of this work.

But as vegetables drink up their adapted nouriſhment perpetually from the moiſt earth, and in conſequence muſt be ſuppoſed to take

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up no more than their perpetual wafte may require, I formerly believed, that this refervoir, or venous fyftem, was not neceffary in vegetables; and that therefore probably it did not exift. I was induced to adopt this idea from having obferved in cutting afunder a ftem of large fpurge, euphorbia heliofcopia; in which the rifing fap could not be miftaken for the milky blood; that much more of the vegetable blood flowed from the upper part of the plant than from the lower part of it; and I therefore fufpected, that there was no returning veins correfpondent to the defcending aortal arteries. But firft this muft neceffarily occur from the veins returning from the root effufing their blood flower than the arteries of the upper part of the plant. And fecondly, if there were no returning veins from the lower part of the plant, there ought to have been no effufion of blood from it. I have fince obferved on cutting afunder a large plant of picris, and alfo a large plant of tragopogon fcorzonera, and inftantly infpecting them with a common lens; that two concentric circles of veffels were vifible, which oozed a milky juice; the internal circle of the upper divifion of the two plants, and the external one of the lower divifion, appeared to bleed more copioufly, and in quicker ftreams, than the external circle of the upper divifion, and the internal one of the lower divifion; whence I concluded, that the veffels of the internal circles were arteries, and thofe of the external ones veins; and that the arteries of the upper part of the plant, which arife from the upper part of the caudex of each individual bud, were thus feen to pour out more blood, and in a quicker ftream, than the veins of the lower part of the plant, as they return from the roots.

Add to this, that as the pulmonary arteries in the green leaves of plants, and in their petals, have correfpondent veins vifible to the eye; and that thefe are alfo feen in the calyxes of fome flowers, which from their other evident ufes can not be efteemed pulmonary organs: There is the ftricteft analogy to believe, that the aortal arteries of the bark of the trunk and roots have alfo their correfpondent veins.

Neverthelefs to evince that the veffels returning from the roots of plants, which oozed out a milky juice, were in reality not abforbent veffels, I cut off the ftem of a large fpurge plant, euphorbia heliofcopia, about a foot and half from the ground, and bent it down into a cup of a decoction of madder, rubia tinctoria, in which it was confined two or three minutes; and wiping the end clean, I prefently cut off about an eighth of an inch of it with a fharp penknife, and obferved with a common lens the large abforbent veffels to be coloured with the madder, while the veins continued to effufe a little white blood; and thus demonftrated both the exiftence of abforbent veffels and returning veins. See Sect. II. 2.

At the fame time the upper part of the plant had alfo its ftem fet in the decoction of madder, and after two or three minutes on cutting off about the eighth of an inch of it, or fimply by wiping the extremity, the large abforbent veffels were feen by the naked eye to be coloured with the madder, and the arteries continued to effufe a large quantity of milky blood. The fame experiments were tried on a plant of tragopogon with the fame event.

It fhould be here obferved, that the decoction of madder fhould be frefh made, as otherwife the colouring matter is liable to form itfelf into molecules, too large to be imbibed by any other veffels but the trunks of the abforbents, which may be faid to refemble the receptaculum chyli of animals, as they pafs from the lower extremity of the caudex of each bud to the upper one.

A proof of the circulation of the juices of plants has been deduced from the communication of white fpots from a grafted fcion to the whole of the tree in which it was ingrafted. Mr. Fairchild budded a paffion-tree, whofe leaves were fpotted with yellow, into one which bears long fruit. The buds did not take, neverthelefs in a fortnight yellow fpots began to fhew themfelves about three feet above the inoculation; and in a fhort time afterwards yellow fpots appeared on a fhoot, a ſhoot, which came out of the ground from another part of the plant. Bradley on Gardening, Vol. II. p. 129.

And Mr. Lawrence obſerves, that the yellow ſtriped jaſſamine has afforded a demonſtration of the circulation of the juices in a tree; he inoculated in Auguſt the buds of ſtriped jaſſamine-trees into the branches of plain ones; and aſſerts, that he has ſeveral times experienced, that if the bud lives but two or three months, it will communicate its virtue or diſeaſe to the whole circumfluent ſap, and the tree will become entirely ſtriped. Art of Gardening, p. 66. Theſe are both of them important facts, as they are related from reſpectable authorities.

And I think I have myſelf obſerved in two pear-trees about twenty years old, whoſe branches were much injured by canker, that on ingrafting hardier pear-ſcions on their ſummits, they became healthier trees, which can only be explained from a better ſanguification produced in the leaves of the new buds.

It has alſo been obſerved by an ingenious lady, that though fruit-trees ingrafted on various kinds of ſtocks are ſuppoſed to bear ſimilar fruit, yet that this is not accurately ſo; as on ſome ſtocks ſhe has known the ingrafted ſcions of apple-trees to ſuffer conſiderable change for the worſe compared with the fruit of the parent-tree; whereas thoſe ſcions, which can be made to grow by ſtriking roots into the earth, ſhe believes to ſuffer no deterioration. If this really occurs, it ſhould be in a very ſlight degree, as the fruit is formed by the action of ſecretion, and depends on the glands of the part more than on any ſlight change of the vegetable blood, from which the ſecretion is ſelected or produced. Nevertheleſs if the fact be aſcertained, it confirms the truth of the exiſtence of a vegetable circulation.

2. The circulation of the vegetable juices in the leaves of plants, and in their trunks and roots, is performed without a heart, and is very ſimilar to that in the aorta of fiſh. In fiſh the blood, after having paſſed through their gills, does not return to the heart, as from the

the lungs of air-breathing animals; but the pulmonary vein, taking the ftructure of an artery, after having received the blood from the gills, which there gains a more florid colour, diftributes it to the other parts of their bodies. A fimilar ftructure obtains in the livers of fifh, as well as in thofe of air-breathing animals; the blood is collected from the mefentery and inteftines by the branches of their proper veins, which unite on their entrance into the liver, branch out again, and affume the office of an artery, under the name of vena portarum, diftributing the blood through that large vifcus for the purpofe of the fecretion of bile; whence we fee in thefe animals two circulations independent of the power of the heart. Firft, that which begins in the mefentery and inteftines, and paffes through the liver; and fecondly, that beginning at the termination of the veins of the gills, and paffing through the other parts of the body; both which circulations are carried on by the action of thofe refpective arteries and veins. Monro's Phyfiology of Fifh, p. 19.

The courfe of the fluids in the leaves, and in the trunks and roots of vegetables, is performed in a fimilar manner. Firft, the abforbent veffels of the roots, of the internal cells, and of the external bark, with the venous blood returning from thofe parts, unite at the foot-ftalk of the leaf; and then, like the vena portarum, an artery commences without the intervention of a heart, and receiving the fap and venous blood fpreads it in numerous ramifications on the upper furface of the leaf; here it changes its colour, and becomes vegetable blood; and is again collected by a pulmonary vein, and returns on the under furface of the leaf. This vein, like that which receives the blood from the gills of fifh, affumes the office of an artery, which correfponds with the aorta of animals, and branching again difperfes the blood upward to the plumula or fummit of the bud, from its caudex at the foot-ftalk of the leaf, and downward along the bark of the trunk to the roots; where it is received by a vein correfponding to the vena cava of animals, after having expended what was required for the fecretions,

tions, excretions, and nutritition, and returns to the caudex of the bud, and to the foot-ſtalk of the leaf.

3. The power, which produces a circulation without a heart in vegetables, acts with an aſtoniſhing force. In ſome of the experiments of Dr. Hales, who fixed glaſs tubes to vine-ſtumps in the ſpring, the ſap-juice roſe above thirty feet; and in ſome trees muſt probably ariſe ſtill higher in the vernal months before the leaves are expended; and this either ſolely by the activity of the abſorbent mouths of theſe veſſels, or aſſiſted by the vermicular action of their ſides, which appear to conſiſt of a ſpiral line, as deſcribed in Sect. II. 7. of this work.

When the ſap-juice riſes thirty-five feet high, which is about the weight of the atmoſphere, the column preſſes about fourteen pounds on every ſquare inch. Now if the area of the mouth of an abſorbent veſſel be only one ten thouſandth part of the area of a ſquare inch, the ten thouſandth part of fourteen pounds is the whole that counteracts the efforts of each abſorbent mouth; and as the veſſels of vegetables appear to have both very minute diameters, and very rigid ſides, they are thence prevented from aneuriſm or rupture by the preſſure of ſo high a column of ſap-juice.

The ſame philoſopher, by fixing glaſs tubes to the arteries of horſes, as near the heart as was practicable, found the blood in them to riſe only nine or ten feet; whence it appears, that a circulation of blood may be carried on more forcibly by the action of the mouths of abſorbent veſſels, than by the apparently more violent exertions of the heart, the power of which was calculated by Borelli and others to be ſo enormouſly great, as to equal the preſſure of ſome thouſand pounds, as the counter preſſure of the moving blood acts on ſo large a ſurface as that of the whole internal ſides of the heart.

But as a column of blood nine feet high preſſes with leſs than one third of the weight of the atmoſphere, or about four pounds on every ſquare inch of ſurface; and as the internal ſurface of the left cavity of the heart of a horſe may not exceed thirty ſquare inches, its whole power does not overcome the reſiſtance of more than 120 pounds.

Hence it becomes intelligible, how the circulation of the blood in the vena portarum of the liver is performed without any apparent pulſation, or contraction of its ſides like an artery, which ſome have indeed ſuppoſed it to poſſeſs, but ſimply by the force of abſorption exerted by the mouths of the veins, which ſupply it with blood.

Secondly, how the circulation of the blood in the bodies of fiſh, except in their gills, is carried on through their ſyſtem without the action of the heart. And thirdly, how the blood in the vena cava of the human body, as well as the fluids imbibed by the lacteals and lymphatics, are carried forwards to the heart by the power alone of their abſorbent mouths, which drink up their blood from the capillaries, or their other fluids from the ſurfaces or cavities of the body. And laſtly, how the whole circulation in vegetables is performed in very minute veſſels without valves, and without a heart, ſolely by the power of abſorption, circumſtances which have long perplexed the phyſiology both of the animal and vegetable kingdoms.

Another circumſtance attending the circulation of the juices in vegetables, as well as the circulation of the blood in animal bodies, has not been ſufficiently attended to; and that is, that the reſiſtance to the paſſage of theſe fluids from the terminations of the arteries, in what are termed capillaries, to the beginnings of the veins, and through the glands of various kinds, is much leſs than is generally imagined, as we ſee with what great force the mouths of both the vegetable and animal abſorbents imbibe their fluids; and that the beginnings of the veins, and the mouths of the lacteals and lymphatics, and probably thoſe belonging to every kind of gland, poſſeſs this great power of abſorption. And that on this account, when wounds are made in trees in the ſummer months, when the umbilical ſap-veſſels of the root have ceaſed to act, ſuch wounds powerfully abſorb any fluid, whether ſalutary or poiſonous, which is applied to them, which does not occur during the bleeding ſeaſon, as the ſap-juice from the diſ-ſevered veſſels of the alburnum ſupplies a greater quantity of fluid than the other parts of the wound can imbibe.

4. The red particles of blood have been ſaid by Lewenhook and others, who have inſpected them in microſcopes, to be of the ſame ſize in all creatures. Hence nature has formed no very ſmall animals with a general circulation of warm red blood; the mouſe and humming-bird are perhaps the leaſt. When it was neceſſary to form the veſſels much more minute, a diluter kind of yellow or milky blood, or one nearly tranſparent, conſtitutes the greateſt part of the vital fluid, as in inſects of various kinds, and in the white muſcles of fiſh; whence aroſe a difficulty to the anatomiſt of viſibly injecting theſe ſmaller ſeries of veſſels, as they are too minute to convey almoſt any coloured particles.

In the vegetable world the finer ſyſtems of their veſſels have ſtill greater tenuity, and hence evade our eyes and microſcopes; and as their coats poſſeſs at the ſame time a greater rigidity, they are in general on that account alſo incapable of receiving coloured injections, which has rendered the anatomy of plants ſo much more difficult to inveſtigate than that of animals, and muſt apologiſe for the imperfections of this part of the work, but affords no argument againſt the exiſtence of a vegetable circulation.

It is probable that by immerſing charcoal, nicely made by ſlow calcination, in quickſilver, or even in melted coloured wax, as it ſo greedily abſorbs almoſt all fluids, when recently taken from the fire, or cooled without the contact of air, we might produce beautiful vegetable preparations, and give more accurate light into the anatomy of plants. But the column of quickſilver employed to puſh forwards the injection ſhould not be too high, leſt it ſhould rupture the veſſels it ought only to fill, as I ſuppoſe has ſometimes happened in thus injecting the glands or capillaries of animal bodies.

5. Recapitulation. We may finally conclude, that the circulation

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of vegetables is performed like that of animals by the irritability of their veſſels to the ſtimulus of the fluids, which they abſorb and protrude; that is, that the extremities of the branching veins of the leaves forcibly abſorb the vegetable blood from the extremities of their arteries, which correſpond with the pulmonary arteries of animals; and that it is thus puſhed on to the foot-ſtalk of the leaf, where the veins unite, and branching out again take the office of an artery, like the aorta in fiſh, without perceptible pulſation. The blood in this artery is puſhed forwards by that behind it, the motion of which was given by the power of abſorption in the pulmonary vein, till it arrives at the extremities of theſe aortal branches, and is there again forcibly abſorbed by the terminations of the correſpondent veins, and again puſhed forwards to the caudex gemmæ, and to the foot-ſtalk of the leaf, like the blood in the vena cava of animals.

A part of this blood is at the ſame time forcibly ſelected and abſorbed by the various glands for the purpoſes of the neceſſary ſecretions, excretions, or nutrition; and the ſap-juice or chyle and the water, which is acquired by the abſorbent veſſels, that correſpond to the lacteal and lymphatic veſſels of animals, is carried, as well as the remainder of the blood, to the foot-ſtalk of the leaf. Here theſe abſorbent veſſels are believed to puſh their contents into the veins correſpondent to the vena cava of animals, and which now uniting without the intervention of a heart, aſſume the name and office of the pulmonary arteries; and branching out upon the leaf expoſe the returning blood and new ſap-juice to the influence of the air. And finally, all this is accompliſhed by the power of abſorption, as in the aortal arteries, and vena portarum, of fiſh, which is excited into action by the irritability of the mouths of theſe veſſels to the ſtimulus of the fluids, which they abſorb.

2d. A circulation of vegetable juices, in every reſpect ſimilar to that in the common leaves above deſcribed, exiſts in the bractes or floral-leaves, except that the leaves of the leaf-bud prepare their juices for

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the production and nouriſhment of other buds in their boſoms; but theſe bractes, which are the lungs of the fructification, prepare their juices for the nouriſhment of the pericarp and its included ſeeds, but not for that of the corol with its anthers and ſtigmas, as theſe in many flowers exiſt before the production of the floral-leaves, as in colchicum and hamamelis.

3d. Another circulation of vegetable juices exiſts in the ſexual parts of flowers, including the nectaries and corols. In the corols the vegetable blood is expoſed to the influence of the air, and prepared for the ſecretion of honey, which is the food or ſupport of the anthers and ſtigmas, as treated of in the ſection IV. V. 1. and in Section VII. 4. In theſe the progreſſion and circulation of the fluids muſt be cauſed by the power of abſorption, which we have ſhewn to be a greater force than that of the heart of animals.

4th. The progreſs of the fluids imbibed by vegetable lacteals from the earth, and by their lymphatics from the air, and from the ſurfaces of their internal cells, is evidently began and carried on by the power of abſorption of their terminating mouths, and the annular contraction of their ſpiral fibres.

5th. And laſtly, the wonderful force with which the ſap-juice is drank up and protruded in the umbilical veſſels, which expands and nouriſhes the buds of trees, and which forms the wires of ſtrawberries above ground, and thoſe of potatoes under ground, with the great variety of bulbs and root-ſcions, is to be aſcribed to this ſingle principle of abſorption. Except that ſome of theſe long cylindric veſſels are evidently compoſed of a ſpiral line, as mentioned in Sect. II. 7. and which may by the annular contraction of this ſpiral line carry the fluids they have abſorbed with great force either in a forward or retrograde direction.

6. Finally I conclude, that the branching abſorbents of the roots unite at the lower caudex of each bud, before it riſes out of the earth,

and forms a large trunk, which paſſes up the alburnum of the tree to the upper caudex of the bud at the foot-ſtalk of the leaf, and may be compared to the receptaculum chyli of animals extended to ſo great a length; and that it there joins the great returning vein, which alſo is compoſed of the branching veins of the roots uniting at the lower caudex of the bud, and aſcending terminates at the upper caudex of it, where it becomes again branched, and forms the pulmonary artery.

The aorta or great artery deſcends, I ſuppoſe, along with the great vein, or vena cava above mentioned; and branching in the roots below, and on all other parts of the individual leaf-bud, performs the offices of ſecretion and nutrition. The pulmonary arteries and veins belong to the leaf; the former expoſes the blood to the atmoſphere beneath a thin moiſt pellicle, whence it becomes oxygenated, and probably acquires ſome warmth, and phoſphoric acid, and the ſpirit of vegetable life. The latter collects the aerated blood by its branches, and conveys it to the upper caudex of the bud, at the foot-ſtalk of the leaf, where it becomes the aorta or great artery above mentioned.

The ſides of the long abſorbent trunks, or receptacles of chyle, which riſe from the lower caudex and terminate in the upper caudex of each bud, as well as the long trunks of the umbilical veſſels deſcribed in Sect. III. evidently conſiſt of a ſpiral line, as well as thoſe trunks of abſorbents, which imbibe aqueous fluids from the air, and a part of their perſpirable matter on the ſurfaces of the leaves. But whether the pulmonary and aortal arteries or great veins conſiſt of a ſimilar ſtructure is not yet aſcertained.

I ſhall here relate the following experiments, which were made a few days ago, to confirm or confute the ideas above delivered.

Some ſtems of large ſpurge, euphorbia, were ſet upright in a decoction of oak-galls, and others in a ſolution of green vitriol. On the next day theſe were reciprocally removed from the one to the other, as by this management I ſuppoſed that the black molecules would

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be produced in the veſſels of the plants, and would thence appear higher in thoſe veſſels than if the black molecules had been formed by a mixture of the two fluids previous to their abſorption.

On cutting theſe horizontally ſlice after ſlice with a ſharp knife, and inſpecting them with a common lens, the milky blood was ſeen to ooze, as before deſcribed, from an external ring of the bark; and an interior ring of coloured points was agreeably viſible many inches up the ſtem; but on ſlicing the ſtem from below up to the inſertion of the leaves and buds in their boſoms, I perſuaded myſelf that I could perceive the coloured abſorbents of the ſtem enlarged at the part where each with the attendant vein changes into a pulmonary artery, and paſſes into the leaf, forming three or more of the ribs of it, and thus conſtituting the upper part of the caudex gemmæ.

Another circumſtance was beautifully viſible, which was, that the coloured cylinder of abſorbent veſſels had evidently ſeparated to allow the new bud to apply its interior termination to the pith; which probably, when it was ſecreted by the glands of the caudex of the parent bud, found in this ſituation a proper nidus, and due nutriment for its embryon ſtate, as in the uterus of the female.

Some other kinds of experiments I directed with deſign to ſhew the part of the lower caudex of each bud, where the branching abſorbents and veins of the root unite each into one trunk, before they aſcend along the bole of the tree; and alſo to ſhew, as in the above experiment, the upper caudex of each bud, where the veins are joined by the abſorbents, and become the pulmonary arteries of each leaf, but did not ſucceed quite to my wiſh, though what I could obſerve ſeemed to confirm the above theory. I had not leiſure to repeat the experiments with ſufficient attention, but ſhall here in few words deſcribe the manner of making them, hoping ſome one may be induced to proſecute them with ſucceſs, and to inject vegetable veſſels, as the anatomiſts do thoſe of animals.

A part of a leaf-ſtalk, and the joint to which it adhered, with about half an inch of the ſtem above and below the joint, were cut off from ſome laſt year's twigs, and alſo the caudex of ſome herbaceous plants. Theſe were covered with ſand in a crucible placed on the fire, till they were red hot, ſo that the vegetable joints were become charcoal. They were then taken out of the ſand, and ſome immerſed in melted ſuet, others in melted bees-wax, others in white paint, and one or two in an amalgama of quickſilver and zinc, which happened to be prepared for the purpoſes of electricity. When they were cold, on ſlicing them, ſome horizontally, and others vertically, I perſuaded myſelf that the blood-veſſels above mentioned, as well as the pulmonary vein and aortal artery, were viſible in the two extremities of the long caudex of the bud, as well as the long trunks of the arteries, veins, and abſorbents, which conſtitute the middle part of it.

SECT.

SECT. VI.

THE GLANDS AND SECRETIONS OF VEGETABLES.

I. 1. Glands *of vegetables. Their veſſels are too minute for coloured injections.* 2. *They poſſeſs appetency. Are ſtimulated by the paſſing blood.* II. 1. Mucilage *in all vegetables.* 2. *Is a part of their nutriment, and convertable into ſugar.* III. 1. Starch *not ſoluble in cold water. Potatoe bread.* 2. *Starch produced from mucilage, whence old grain better than new. Alum coagulates mucilage. Uſe of it in bread. How diſtinguiſhed in bread by the eye. Is ſalutary in London bread. Is uſed in making hair-powder.* 3. *Froſt converts mucilage into ſtarch; ſnow pancakes.* 4. *Starch from poiſonous plants is wholeſome, and may be obobtained by elutriation in times of ſcarcity.* IV. 1. Oils *may be ſeparated from bitter or narcotic materials, as the latter adhere to the mucilage.* V. 1. Sugar *formed by animal digeſtion.* 2. *By vegetable digeſtion. Sugar is nutritive, but may injure the teeth.* 3. *In many roots it is found ready prepared. May be ſeparated from mucilage by vinous ſpirit.* 4. *Exiſts in fruit formed from auſtere acids by a vegetable proceſs* 5. *By heat; by bruiſing auſtere fruit; by drying malt. Sugar converted into ſtarch as well as ſtarch into ſugar. Uſe of ſugar to vegetables and animals.* VI. 1. Honey *guarded from inſects, and from rain.* 2. *Is of great importance. Is expoſed to the air. Is reabſorbed, and is nutritious.* 3. *Depredation of inſects on honey is injurious to vegetation. So is the honey-dew on trees. Bees alſo collect farina from flowers.* 4. *Why the honey is expoſed to the air. Is the food of the anthers and ſtigmas. Differs from ſugar by greater oxygenation. Benevolent economy of nature.* VII. 1. Wax *preſerves the anther-duſt from rain. How wet ſeaſons injure wheat.* 2. *Wax collected from ciſtus labdiniferus. Bees much injure flowers.* 3. *Wax from candleberry-myrtle, and from croton ſebiferum. Preſerves or nouriſhes the immature ſeeds.* 4. *Wax depoſited on plants by inſects in China. Gives conſiſtence to oil.* VIII. 1. Turpentines and eſſential oils *are inadmiſſible with water. Moiſt parts of vegetables are ſooneſt deſtroyed by froſt. Evergreen trees contain moſt reſin. Defends the buds of deciduous plants.* 2. *Origin of petroleum, jet, amber, foſſil, coal.*

coal. 3 *Eſſential oils agreeable. Poiſonous. Preſerve wood from inſects. Uſed in Africa to poiſon weapons and pools of water.* 4. *Some eſſential oils burſt into flame with nitric acid. Produce a vapour round dictamnus fraxinella.* 5. *Elaſtic reſin. Bird-lime. Reſinous part of wheat-flower.* IX. 1. Bitter, narcotic, acrid juices, *for the defence of plants. Opium exiſts in the poppy-head, but not in the ſeed. So of hyoſcyamus. Narcotic matter in walnut-huſks not in the ſeed. Oil of bitter almonds taſteleſs.* 2. *Acrid, aſtringent, emetic, cathartic, and colouring matters. Many poiſonous plants in all our hedge-bottoms.* 3. *All theſe are ſtrongeſt in the hybernaculum or winter-lodge of plants. When oaks ſhould be decorticated.* X. 1. Acids *in fruit and leaves of various kinds. Convertible into ſugar. For the nutriment of ſeeds and buds. For the defence of the plants.*

I. 1. THE ſtructure of the glands of animals has not been yet fully aſcertained. They conſiſt of veſſels ſo minute as to exclude all coloured injections, except quickſilver; and the terminations of theſe veſſels are ſo tender, that the neceſſary weight of the quickſilver is liable to break them, and thus miſinform the obſerver, as mentioned in Sect. V. 4. Little more is therefore known of them than their effect, which is, that they ſecrete, that is ſeparate or produce, ſome fluid from the blood; as bile, ſalvia, urine, milk.

The veſſels of vegetables being ſtill more minute, and more rigid, the ſtructure of their glands is ſtill further removed from our diſcovery. Their effects are however as evident as thoſe of the glands of animals in the ſecretion or production of various fluids, which become ſolid, as their aqueous parts are abſorbed or exhaled, as mucilage, ſtarch, oil, ſugar, honey, wax, turpentines, eſſential oils, aromatics, bitters, narcotics, acrids, acids, and a variety of other materials, which fill our barns and granaries, and crowd the ſhops of the druggiſt.

2. There can be no doubt from what has been already ſaid of the circulation of vegetable juices, but that their various ſecretions muſt be effected in a ſimilar manner to that in animal bodies, which is believed

believed to be performed by the mouth of each gland being irritated into action by the ſtimulus of the blood, which is brought to it, and that by a kind of appetite it drinks up a part of the blood, and converts it to the fluid, which it ſecretes, which then becomes more or leſs ſolid, as its aqueous parts are abſorbed or exhaled.

II. 1. Mucilage is found in all parts of plants, as being an eſſential conſtituent of vegetable as of animal bodies; ſo when an extract is made by boiling plants in water, the mucilage makes the greateſt part of this extract. The mucilage called gum arabic is obtained from mimoſa nilotica, gum tragacanth exſudes from aſtragalus tragacantha, as a ſimilar gum exſudes from our cherry and plumb-trees; ſagoe is the pith of the lycas circinalis; and ſalep is the root of the orchis dried in an oven.

This mucilage ſeems to ſerve as nouriſhment to the plant; firſt, becauſe it is found in all vegetable as well as animal materials, as they decompoſe in dunghills; ſecondly, becauſe it forwards the growth of vegetables, when ſpread upon land; thirdly, becauſe thoſe trees, which bleed much gum, are weakened and frequently die; and laſtly, becauſe it is evidently laid up in the roots and ſeeds of various vegetables for the nouriſhment of the young plants. But in theſe it ſeems to undergo a change either in part chemical, or wholly by the digeſtive organs of the embryon plant, and is converted into ſugar, as in the tranſmutation of barley into malt; and as appears from the ſweet taſte of onions and potatoes, when boiled after they have germinated; and as ſugar abounds in the vernal ſap-juice of trees in ſuch quantity as to be capable of fermentation.

III. 1. Starch is another kind of mucilage, which differs from thoſe above mentioned in its property of not diſſolving in cold water, and can hence be eaſily ſeparated from them. If eight pounds of good raw potatoes be grated by means of a bread-grater into cold water; and, after well agitating the mixture, the ſtarch be ſuffered to ſubſide; and this ſtarch be then mixed with eight other pounds of boiled potatoes, as good bread may be made as from the beſt wheat flour; as is affirmed by Monſ. Parmentier. From this it appears, that the quantity of ſtarch in potatoes and in wheat produces the principal difference of their reſpective flours. See Zoonomia, P. III. Article I. 2. 3. 4.

2. There is reaſon to believe that the mucilage during the growth of the plant is converted into ſtarch; and that this proceſs continues in grain ſome time after it is carried into the barn or granary, which occaſions old wheat to produce better flour for the baker; and old oats and old beans are univerſally believed to give more nouriſhment to horſes. I ſhall here add a conjecture, that I ſuppoſe the uſe of alum in making bread conſiſts in its coagulating the mucilage, and perhaps thus contributing to convert it into ſtarch; for the bakers mix it principally with new wheat; and affirm, that it makes the flour of new wheat equal to old.

Where much alum is mixed with bread, it may be diſtinguiſhed by the eye by a curious circumſtance, which is, that where two loaves have ſtuck together in the oven, they break from each other with a much ſmoother ſurface, where they had adhered, than thoſe loaves do which do not contain alum.

Add to this, that alum is alſo uſed by the London bakers for the purpoſe of clearing the river water, with which they are ſupplied, which is frequently muddy; and alſo for inſtantaneouſly deſtroying the volatile alkali, which is ſaid to exiſt in ſome London wells owing to the vicinity of dunghills. Theſe purpoſes it probably fulfils by coagulating the mucilage, which may occaſionally be mixed with the water and ſupport the mud in it; or by uniting with the calcareous earth, or with the volatile alkali which it may contain, and depoſiting the new-formed gypſum, or its own argillaceous baſe, the deſcent of which may carry down other impurities along with it, in the ſame manner as ſome muddy wines have been rendered fine, not by filtering them through ſand, as then the mud retained on the ſurface

ſurface of the ſand ſoon prevents the deſcent of the wine through it, but by paſſing clean ſand in ſhowers by means of a riddle through the wine. Alum is ſaid to be uſed by the Chineſe for the purpoſe of cleaning the water of ſome ſtagnant reſervoirs; and when uſed in ſmall quantity may in all theſe reſpects be rather ſalutary than injurious to the bread of London.

Alum is ſaid alſo to be uſed in the manufactory of hair-powder, which ſhould conſiſt of ſtarch without mucilage, that the hair may not be glued together by the perſpirable matter of the head, or by an accidental ſhower. Whether it has the property of converting mucilage into ſtarch might be eaſily aſcertained by experiment, by waſhing in cold water alone one parcel of wheat flour, and waſhing a ſimilar parcel in a ſolution of alum in water.

3. Another conjecture I ſhall introduce here is, that it is probable that the action of froſt alſo may tend to coagulate mucilage, or convert it into ſtarch; for in the colder parts of Britain it is ſaid, that the corn never ripens till they have froſty nights; and I well remember many years ago having obſerved, that ſome book-binder's paſte made by boiling wheat-flour and water, after it had been frozen, ceaſed to cohere on being preſſed together, like the crumbs of ſome bread; and I have been told by ſome houſewives that their pancakes become much lighter if ſnow be mixed with the flour inſtead of water. See Sect. XVI. 3. 2.

4. Now as ſtarch is not ſoluble in cold water, the bitter and acrid particles of plants may be waſhed from it along with the mucilage; whence in times of ſcarcity this nouriſhing part of vegetables may be obtained by elutriation from poiſonous plants; on this circumſtance principally depends the wholeſomeneſs of the bread made from the caſſava, the acrid and poiſonous particles being previouſly waſhed away along with the mucilage. Monſ. Parmentier found the ſtarch from the root of the white bryony to contain no acrimony, and to be a wholeſome article of food.

IV. 1. Many feeds contain much oil mixed with their mucilage, or ftarch; as nuts, almonds, flax-feed, rape-feed. Some of thefe contain alfo a bitter or narcotic material, as bitter almonds, apricot kernels, acorns, horfe-chefnuts; which, as it adheres to the mucilage, may be feparated from the oil; as in expreffing the oil from bitter almonds, which is as good as from fweet ones. And it is probable by grating to powder, and wafhing in cold water, the kernels of acorns, and horfe-chefnuts; or fimply by preffure, that a wholefome ftarch, or oil, might be procured. It is probable alfo that the roots of fern treated in this manner would afford good nourifhment, as thefe are faid to be eaten by the inhabitants of New Zealand, and have been ufed in this country in times of great fcarcity. And that the roots of nymphæa, water-lily, might be thus made into wholefome bread, (which are faid to have been eaten in Egypt by Herodotus) and the roots of many other water-plants, which might thus become articles of fubaquatic agriculture, which is an art much wanted in this country. See Sect. XI. 2. 5. and XVII. 2. 3.

V. 1. The digeftive power of animals feems to be principally exerted in converting their food into fugar; fince the chyle of all animals refembles milk, which contains much fugar, and thence fpontaneoufly runs into fermentation, which terminates in the production of acid, as in butter-milk. In Siberia the natives diftil a fpirituous and intoxicating liquor from milk thus fermented. Gmelin. In the diabetes there is reafon to believe, that the chyle paffes off into the bladder without being previoufly mixed with the blood; and there is a curious hiftory of a patient in the infirmary at Stafford, who laboured under a diabetes, he eat and drank thrice as much as moft moderate men, and from fixteen to eighteen ounces, and even twenty ounces of coarfe fugar was extracted for fome time daily from his urine. Zoonomia, Vol. I. Sect. XXIX. 4.

2. In like manner the digeftive powers of the young vegetable, with the chemical agents of heat and moifture, convert the ftarch or

mucilage

mucilage of the root or ſeed into ſugar for its own nouriſhment; or they obtain ſugar ready prepared for them from ſome roots, as the beet-root; from many fruits, as grapes, pears, peaches; from the milk of cocoa-nuts, and from the ſap-juice of the ſugar-maple, birch, and many other trees. And thus it appears probable, that ſugar is the principal nutriment of both animal and vegetable beings. That it is the moſt nutritive part of vegetable ſubſtances is evinced by the well aſcertained fact, that the ſlaves in Jamaica grow fat in the ſugar-harveſt, though they endure at that time much more labour.

Yet there is an idle notion propagated amongſt the people that ſugar is unwholeſome; it is indeed probable, that the moſt nouriſhing materials may be taken more eaſily to exceſs, but not that it is therefore in general unwholeſome; at the ſame time it is probable, that ſome fruits preſerved in ſyrup, or ſweet-meats, may contribute to deſtroy the teeth; ſince, if the ſugar ſhould become in a ſtate of decompoſition, and the ſaccharine acid ſhould abound, it will diſſolve calcareous earth with greater avidity than any other acid.

3. In many plants ſugar is found ready prepared, as above mentioned; thus in the beet-root, the cryſtals of it may be diſcerned by a microſcope; and may be extracted from the mucilaginous matter of the root by diſſolving it in rectified ſpirit of wine; which will unite with ſugar but not with mucilage. In the joints of graſs and of corn it may be diſcovered by the taſte. In the manna-aſh, fraxinus ornus, the ſame ſaccharine matter is produced along with the eſſential ſalt of the plant, which is purgative; and in the ſugar-cane it abounds in ſuch large quantity as to contribute much to the nouriſhment of mankind. And,—and what?—Great God of Juſtice! grant, that it may ſoon be cultivated only by the hands of freedom, and may thence give happineſs to the labourer, as well as to the merchant and conſumer.

4. Another ſource of ſugar in vegetables is in the fruit, which in many plants changes from an auſtere acid to a ſaccharine acid, as in gooſeberries,

goofeberries, apples, oranges. This change continues to proceed after the pears and apples, or oranges, are taken from the tree into our ftorehoufes, but the fruit in this fituation continues to ripen by a vegetable procefs, as it can not be faid to be dead, becaufe it does not yet undergo fermentation or putrefaction, or other chemical diffolution; and though its progrefs in ripening may be forwarded by warmth, yet it muft ftill be afcribed to a vegetable procefs; as the plants themfelves grow quicker when expofed to additional heat.

5. But there are other means of increafing or haftening the faccharine procefs in auftere vegetable fruits, as by bruifing them, or by baking them, both which muft deftroy the life of the fruit; thus when apples are bruifed for the purpofe of making cyder, they become fweeter even in the act of bruifing them; and many pears change from an auftere to a fweet juice fimply by the heat of baking; and it is probable that malt acquires a great part, though not the whole of its faccharine matter, in the act of drying. This chemical production or increafe of fugar in vegetable juices is worth being further inquired into; fince if fugar could be made from its elements without the affiftance of vegetation, fuch abundant food might be fupplied as might tenfold increafe the number of mankind!

It is a curious circumftance not yet fufficiently underftood, that not only ftarch appears to be convertible into fugar by the vegetable procefs of digeftion, as in the germination of farinaceous feeds; but that fugar is capable of being converted into ftarch, as appears in the ripening procefs of fome pears, which firft contain a fweet-juice, and afterwards become mealy.

The ufe of this faccharine matter of the fruit or fap-juice in the vegetable economy is for the purpofe of fupplying the young feed or bud with nourifhment to enable it the better to ftrike its roots into the earth, and to elevate its leaves into the air, and thus by its quicker

quicker growth to rival its neighbours in their contentions for air, and light, and moifture, which are neceffary for its exiftence.

VI. 1. The production of honey is perhaps one of the moft important vegetable fecretions, except that of the prolific farina from the anthers; and of the favilla, or new embryon, in the axilla of the leaf. The glands for this purpofe, or certainly the refervoirs, which contain the honey after it is fecreted, are in many flowers vifible to the naked eye; as in crown-imperial, fritillaria imperialis; in monkfhood, aconitum napellus; hellebore, ranunculus. It is neverthelefs probable, that this refervoir of honey is frequently placed at a diftance from the gland, which fecretes it, for the purpofe of preferving it from infects and from rain, which is often effected both by a very complicated apparatus, and by an acrid or poifonous juice, as in the aconites and the hellebores above mentioned.

As the nectary, or honey-gland, always falls off along with the corol, and anthers, and ftigmas; thefe appear to be parts or appendages to each other. The vegetable blood is expofed to the air in the corol, and thus is oxygenated or prepared for the fecretion of this important fluid; which I fuppofe is again reabforbed, and fupplies nourifhment to the anthers and ftigmas. Some acrid juices, and odorous particles, are at the fame time fecreted from the blood thus oxygenated in the corol; which feem defigned as one kind of defence againft the depredations of infects on this important refervoir of honey.

2. The univerfality of the production of honey in the vegetable world, and the very complicated apparatus, which nature has conftructed in many flowers, as well as the acrid or deleterious juices fhe has furnifhed thofe flowers with, as in the aconite, to protect this honey from rain, and from the depredations of infects, feem to imply, that this fluid is of very great importance in the vegetable economy; and alfo that it was neceffary to expofe it to the open air previous to its reabforption into the vegetable veffels.

In

In the animal ſyſtem the lacrymal gland ſeparates its fluid into the open air for the purpoſe of moiſtening the eye; of this fluid the part, which does not exhale, is abſorbed by the puncta lacrymalia, and carried into the noſtrils; but, as this is not a nutritive fluid, the analogy goes no further than its ſecretion into the open air, and its reabſorption into the ſyſtem. The perſpirable matter is another material ſecreted by animal glands into the external air, and is in part reabſorbed, and in part exhaled. And every other ſecreted fluid in the animal body is in part abſorbed again into the ſyſtem, even thoſe which are eſteemed excrementitious, as the urine; and others are probably entirely reabſorbed, as the bile, ſaliva, and gaſtric juice.

That the honey is a nutritious fluid, perhaps the moſt ſo of any vegetable production, appears from its great ſimilarity to ſugar, and from its affording ſuſtenance to ſuch numbers of inſects, which live upon it ſolely during ſummer, and lay it up for their winter proviſion. Theſe proofs of its nutritive nature evince the neceſſity of its reabſorption into the vegetable ſyſtem for ſome uſeful purpoſe.

3. It is probable, that the depredations of inſects on this nutritious fluid muſt be injurious to the products of vegetation; and would be much more ſo, but that the plants have either acquired means to defend their honey in part, or have learned to make more, than is abſolutely neceſſary for their own economy. Thus in ſilene, catch-fly, and in droſera, ſun-dew, it is defended by a viſcid juice from the attack of inſects; in hellebore, and in aconite, it is defended by the difficult paſſage to it, and by the acrid juice of the plant, if inſects ſhould endeavour to creep into the nectary, or pierce it with their proboſcis; and in polygonum melampyrum, buck-wheat, and in cacalia ſuaveolens, alpine colts-foot, there ſeems to be a ſuperabundant quantity of honey ſecreted, as thoſe flowers are perpetually loaded with bees and butterflies, inſomuch that at Kempton-land in Germany, Mr. Worlidge ſays, in his Myſteries of Huſbandry, Ch. IX. 3. that he ſaw forty great bee-hives filled with honey to the amount of

feventy pounds in each in one fortnight by their being placed near a large field of buck-wheat in flower; and I well remember being myfelf aftonifhed at feeing the number of bees on a field of buck-wheat in Shropfhire, as well as on a plant of cacalia fuaveolens in my garden; from which the fcent of honey could be perceived at many feet diftance from the flower.

In the fame manner the honey-dew on trees is very injurious to them; in which difeafe the nutritive fluid, the vegetable fap-juice, feems to be exfuded by a retrograde motion of the cutaneous lymphatics, as in the fweating ficknefs of the laft century, or is devoured by infects, which pierce the lymphatic veffels of the leaves at midfummer, feed on the vegetable chyle, and void it almoft unchanged. See Sect. III. II. 8. and XIV. I. 7.

To prevent the depredation of infects on honey a wealthy man in Italy is faid to have poifoned his neighbour's bees, perhaps by mixing arfenic with honey, againft which there is a flowery declamation in Quintillian, No. XIII. This mixture of honey and arfenic may be ufed with effect to poifon flies, which fometimes abound in pernicious multitudes; for the flies which frequent our houfes are liable to great thirft, as is feen by their drinking any fluid, which is diffufed on a table; whence if a flight folution of arfenic, with a little fugar, be put thinly on a plate or two, and fet on chimney-pieces or windows, the flies will eagerly drink it, and perifh almoft inftantly. It is probable that wafps might be thus deftroyed in hot-houfes, if a little honey was added to attract them by its odour.

As the ufe of the wax is to preferve the duft of the anthers from moifture, which would prematurely burft them, the bees, which collect this for the conftruction of the combs or cells, and collect the farina alfo probably for bee-bread for their larvæ or maggots, muft on both thefe accounts alfo injure the vegetation of a country, where they too much abound.

4. It is not eafy to conjecture, why it was neceffary, that this fecre-

tion of honey ſhould be expoſed to the open air in the nectary or honey-cup; for which purpoſe ſo great an apparatus for its defence from inſects and from ſhowers became neceſſary. This difficulty increaſes, when we recollect, that the ſugar in the joints of graſs, in the ſugar-cane, and in the roots of beets, and in ripe fruits, is produced without expoſure to the air. But on ſuppoſition of its ſupplying nutriment to the anthers and ſtigmas, it may thus acquire greater oxygenation for the purpoſe of producing the greater powers of amatorial ſenſibility, as mentioned in Sect. IV. 5. 6. and probably in this circumſtance alone differs from ſugar.

From this proviſion of honey for the male and female parts of flowers, and from the proviſions of ſugar, ſtarch, and mucilage, in the fruits, ſeeds, roots, and alburnum of plants, laid up for the nutriment of the young progeny; not only a very numerous claſs of inſects, but a great part of the larger animals, procure their food. Surely this muſt be called a wiſe proviſion of the Author of nature, as by theſe means innumerable animals enjoy life and pleaſure without producing pain to others; for the embryons in theſe buds, ſeeds, or eggs, as well as the nutriment laid up for them, are not yet endued with ſenſitive life. There is another ſource of nutriment provided for young animals, which ſtill further evinces the benevolence of the Author of nature; and that is the milk furniſhed by the mother to her offspring; by this beautiful contrivance the mother acquires pleaſure in parting with a nutritious fluid, and the offspring in receiving it!

VII. 1. The wax is another vegetable ſecretion produced with the fecundating duſt on the anthers of flowers, which in wet ſeaſons it preſerves from rain, to which it is impenetrable; for the farina, or fecundating duſt of plants, is liable to ſwell if expoſed to much moiſture, and to burſt its ſhell; and it either then becomes inert and ineffectual, or is waſhed away. Whence Mr. Wahlborn obſerves, that as wheat, rye, and many of the graſſes, and plantain, lift up their anthers on long filaments, and thus expoſe the encloſed fecundating duſt to be waſhed away by the rains; a ſcarcity of corn is produced in wet ſummers; hence the neceſſity of a careful choice of ſeed-wheat; as that, which had not received the duſt of the anthers, will not grow, though it may appear well to the eye.

2. A ſubſtance ſimilar to this is ſaid to be collected from extenſive underwoods of the ciſtus labdaniferus in ſome eaſtern countries by this ſingular contrivance; long leathern thongs are tied to poles, and drawn over the flowers of theſe ſhrubs about noon, which thus collect the wax or reſin with part of the anther duſt, which adheres to the leathern thongs, and is occaſionally ſcraped off for uſe. Thus in ſome degree the depredation of the bee is imitated, except that ſhe loads her thighs only with the anther-duſt, which according to Mr. John Hunter conſtitutes the bee-bread found in hives for the ſupport of the larva or bee-maggot; and that ſhe ſwallows the wax for the conſtruction of her combs, as well as the honey for her winter provender; and thus every way injures the fecundity of flowers.

3. A wax in America is obtained from the myrica cerifera, candleberry myrtle, the berries of which are boiled in water, and the wax ſeparates. The ſeeds of the croton ſebiferum are lodged in a kind of tallow; in both theſe plants the wax or tallow probably ſerves the purpoſe of preſerving the immature ſeeds from moiſture; or like the oil found in flax-ſeed, rape-ſeed, and in many kernels, they may conſtitute in part the nouriſhment of the new plant.

It muſt neverthеleſs be obſerved, that Mr. Sparman ſuſpects, that the green wax-like ſubſtance on the berries of the myrica cerifera is depoſited by inſects. Voyage to the Cape, V. I. p. 145. And Du Halde deſcribes a white wax made by inſects in great quantity round the branches of a tree in China, which is called Tong-tſin. Deſcript. of China, V. I. p. 230. And laſtly, ſir G. Staunton mentions a white wax on a plant in Cochin-China, which he believes to be ſtrewed on the plant in the form of white powder, which has this ſingular property, that one part of this white powder mixed with three parts of olive oil made hot, gave it when cold the confiftence of bee's-wax. Embaffy to China, Vol. I. p. 354.

VIII. 1. Turpentines or balfams, refins, and effential oils, are analogous to the vegetable fecretions laft mentioned, in their being inadmiffible with water. Thofe vegetables, which contain in their veffels the leaft water, bear cold climates the beft; becaufe when water is frozen, it occupies more fpace than before; and hence burfts the bottles which contain it; in the fame manner when any fucculent vegetable is frozen, its veffels become burft or bruifed by the expanfion of the ice, and the plant is deftroyed; on this account thofe parts of plants, which are the moft juicy, as the laft fhoots of vines, are fooneft deftroyed in winter. Hence many of the evergreen trees of this climate are replete with turpentine or refin, which by occupying the place of fo much water, contributes to their hardinefs. There is alfo a partial fecretion of balfam or turpentine in many deciduous plants for the purpofe of defending their buds during the winter, both from froft and from wet, which is repelled by their balfamic varnifh, as on the buds of the populus tacamahacca.

2. The balfams and refins of the fhops are either extracted from the wood by fire, or exfude from wounds of the tree; thus what is called Venice turpentine is obtained from the larch by wounding the bark about two feet from the ground, and catching it as it exfudes. Sandarach is procured from common juniper, and incenfe from another juniper; and there is reafon to believe that bitumen, or petroleum, with jet, amber, and all the foffile coal in the world, owes its inflammable part to the recrements of deftroyed forefts of terebinthinate vegetables, fo important to the prefent race of mankind has been this vegetable fecretion!

3. The effential oils are fometimes raifed by diftillation from balfams or refins, as oil of turpentine; but are chiefly extracted from flowers; where their office has been to prevent the depredations of infects; though many of them are fo agreeable to the human fenfe of

fmell,

ſmell, when theſe eſſential oils are diſſolved or mixed with water in diſtillation, they have been called the ſpiritus rector of the plant, and conſtitute the odour of it, whether aromatic or fetid.

Some of theſe eſſential oils poſſeſs the moſt poiſonous qualities, as thoſe of lauro-ceraſus, and of tobacco; and are uſed by Indian nations for the purpoſe of poiſoning their weapons, which they cover like a varniſh. And hence ſome of the reſinous woods are ſaid never to be devoured by inſects, as the unperiſhable cheſts of cypreſs, in which the Egyptian mummies have been preſerved for ſo many ages, and the cedar in which black lead is incloſed for pencils.

The acrid poiſon of the large euphorbium of Africa exiſts in the oil of that plant; as M. Vaillant obſerves, that the natives ſometimes poiſon the waters with ſlicing this plant into them, and that the poiſonous oil ſwims upon the ſurface, and may thus be avoided by a careful drinker. This in a country where water is ſcarce, and generally in ſtagnant pools, may be readily effected; as a few ſpoonfuls of oil will cover a large ſheet of water, as it becomes diffuſed upon it without friction, as mentioned in Botanic Garden, Vol. I. Addition. Note XXIX.

4. Some of the eſſential oils are ſo inflammable as to burſt into a vehement flame on being mixed with nitrous acid, as oil of cloves; and even the ſmall quantity diffuſed in the air round the dictamnus fraxinella will take fire on a ſtill evening at the approach of a lighted candle.

5. With theſe ſhould be arranged the elaſtic reſin called Caoutchouc, which is ſaid to exſude from a tree in Guaiana, called Iatropha elaſtica, by M. de la Borde, phyſician at Cayenne. A ſimilar elaſtic reſin is ſaid to be obtained from a plant in Madagaſcar, called Finguere, a kind of wild fig-tree, according to Abbe Rochon; and the bird-lime extracted from the bark of the hollies of our climate ſeems to be a ſimilar material; as like the caoutchouc it becomes ſoft by heat, and is impenetrable by water, but ſoluble in ether. Another elaſtic ſub-

ſtance,

ſtance, which is inſoluble in water, is procured from wheat by long maſtication, or by agitating the flour of it in water; which has been ſaid to approach to animal matter, and is believed to be the moſt nutritious part of that aliment, and was once much talked of, or ſold under the name of alimentary powder for the nouriſhment of marching armies.

IX. 1. The bitter, narcotic, and acrid juices of plants are ſecreted by their glands for the defence of the vegetable from the depredation of inſects and of larger animals. Opium is found in the leaf, ſtalk, and head of the poppy, but not in the ſeeds. A ſimilar narcotic quality exiſts in the leaf and ſtem of hyoſcyamus, henbane, but not in the ſeeds. An acrid juice exiſts in huſks of walnuts, and in the pellicle, or ſkin, of the kernel; but not in the lobes, or nutritious part of it. Theſe ſeem to have been excluded from the ſeed, leſt they might have been injurious to the tender organs of digeſtion of the embryon plant. In ſome ſeeds, however, there is a bitter quality, but which refuſes to mix with the oleagenous part; as the oil expreſſed from bitter almonds is as taſteleſs as that from the ſweet almonds.

2. Other vegetables poſſeſs glands adapted to the ſecretion of various fluids more or leſs aromatic, acrid, or aſtringent; as the herb of water-creſs, the root of horſe-radiſh, the ſeeds of muſtard, the flowers of roſes, the fruit of quince, and the bark of oak. To theſe ſhould be added thoſe which have emetic and cathartic qualities; and other vegetable preparations, which are uſed in the arts of dying, tanning, varniſhing; and which ſupply the ſhops of the druggiſt with medicines and with poiſons. All which deleterious juices ſeem to have been produced for the protection of the plant againſt its enemies, as appears by the number of poiſonous vegetables, which are ſeen in all our hedge-bottoms and commons, as hyoſcyamus, cynogloſſum, jacobæa, and common nettles; which neither inſects nor quadrupeds devour, and which are therefore of no known uſe but to themſelves; and poſſeſs

poſſeſs a ſafer armour in this panapoly of poiſon, than the thorns of hollies, briars, and gooſeberries.

3. As the bitter, narcotic, acrid, and terebinthinate, as well as the farinaceous, oily, and ſaccharine matters, are ſecreted in ſummer from the vegetable blood, and reſerved for the nutrition and defence of the new buds and bulbs, they are in this climate generally found more concentrated in the hybernaculum, or winter-lodge of plants, before the new ſap is raiſed by the umbilical or abſorbent veſſels in the ſpring. Hence roots and barks, as well as fruits and ſeeds, are beſt collected in autumn, or in winter, for the purpoſes of medicine or of other arts.

Thus the bark of oaks ſhould be taken off for the uſe of the tanner in the winter, or in early ſpring, before the leaves pullulate, as then a great part of its aſtringent or bitter juices is reabſorbed, and carried to the new foliage along with the ſaccharine ſap-juice, which has been depoſited in the cells of the alburnum or ſap-wood. But as the barks of trees become looſer, and much more eaſily detached from the wood, when the ſap-juice riſes in the ſpring, this is the beſt time for debarking them; but the naked bole and branches ſhould ſtand till autumn, till the ſaccharine matter collected in the alburnum has been expended in unfolding the new leaves; otherwiſe it will ſoon ferment and putrefy; and the ſap-wood will thus quickly decay by what is termed the dry-rot of timber, as mentioned in Sect. III. 2. 3.

X. 1. The acids produced by vegetable ſecretion have of late been much ſubjected to chemical inquiry, and have been found to be ſo numerous, that they have been named from the vegetables, or parts of vegetables, from which they have been extracted; as the gallic acid, malic acid, oxalic acid. Many unripe fruits contain an auſtere acid, which is gradually converted into ſugar by vegetable or chemical proceſſes for the nutriment of their ſeeds, as deſcribed in No. V. 4. of this ſection. In other plants it exiſts in the foot-ſtalks of the leaves,

as

as in rheum, rhubarb; or in the leaves themſelves, as in oxalis, ſorrel; in theſe ſituations alſo I ſuppoſe it is ſecreted both for the defence of thoſe plants from the depredation of inſects and of larger animals; and alſo for the purpoſe of its being converted into a ſaccharine juice by the digeſtion of the young bud in the boſom of the leaf.

SECT.

SECT. VII.

THE ORGANS OF REPRODUCTION OF VEGETABLES.

The theory of Linneus for vegetable reproduction too mechanical, and without analogy. Every new fluid is secreted by glands, as the liquor amnii and albumen ovi. So also is the favilla vitæ, or living entity. I. 1. Lateral progeny. *The new bud is secreted in the axilla of the leaf, and requires no female apparatus. It adheres to its parent not by inosculation of vessels, but resembles the chick in the egg.* 2. *Difference of the chick and fetus. Their nutriment and oxygenation. The embryon may be seen in the buds of horse-chesnut. It is a paternal progeny.* 3. *This lateral offspring resembles the parent. Not universally so. More perfect than seeds. Buds of diœcious plants bear similar sexes. The lateral progeny degenerates from hereditary diseases. Whence curled potatoes, blighted strawberries, bears fruit at the same time, and of the same kind. Plants live longer if prevented from flowering. Art of producing double hyacinths, ranunculus, tulips.* 4. *Lateral progeny of corallines and sea-anemonies. Polypi are all males. Wires of knot grass like the joints of the tape-worm, which are all males.* 5. *Aphis, viviparous and oviparous like vegetable generation.* 6. *Vessels of the bud and leaf do not inosculate. Viviparous, oviparous, and paternal generation.* 7. *Leaves on twigs like the progeny of volvox. But in some twigs the pith is divided, and the buds successive. Hermaphrodite generation. Buds from every part of the caudex. Those from below the graft are like the stock. Find numerous uteri like eggs and spawn. Paternal generation preceded sexual generation. The last more excellent.* II. 1. Sexual progeny. *Seeds before impregnation. Eggs before impregnation. Seed-embryon suspended by opposite points like the cicatricula of the egg.* 2. *Seed-bud and flower. Stamens and stigmas. Males bend to females, and females to males. Style of spartium bends round like a French horn. Onanism of epilobium. Male flowers of vallisneria swim to the females. Flowers with long filaments injured by rain. Submarine plants project a liquor.* 3. *The petals are respiratory organs.* 4. *Honey is the food of the anthers and stigma; which like butterflies propagate and die.*

5. Seeds are formed and nourished by the umbilical vessels previous to fecundation, or by the bractes or floral-leaves. Dispersion of seeds by plumes, by hooks, by twisted awns. Creep on the ground. Hygrometer of a geranium seed. 6. Sexual generation the chef d'œuvre of nature. Produces variety of species. Mixed breed of cabbage. Mixed breeds of beans. An apple sour on one side. Vegetable mules. 7. Animal mules. They externally resemble the male, internally the female. Mule from the horse and female ass. From the mare and male ass. From Spanish rams and Swedish ewes, and the contrary. From the goat of angora. Ram without horns. 8. How to improve the varieties of fruits and flowers, and produce new ones. Many plants were originally mules, and many animals. How to produce new animal monsters, both quadrupeds and fish, by the method of Spallanzani. Mules more frequent in antient times. III. Vegetable generation. *1. A triple tree by ingraftment. The caudex of each bud is triple. Lateral or paternal mules. Conferva fontinalis splits. 2. The lateral propagation of the polypus. The hydra stentorea splits. Two halves of different polypi unite. So the vegetable filaments or caudexes in ingrafted trees. 3. Triple lateral mule. Each part of the triple caudex is produced from that in its vicinity, not from the plumula of the bud. 4. Worms multiplied by dividing them. So the caudexes of the buds of trees. 5. The parts of the long caudexes of trees are secreted from the adjoining parts of the parent caudexes, and combine beneath the cuticle of the tree. Every part of a compound caudex can produce a new bud, resembling the part of the compound stock, where it rises. Lateral mules consist of parts from three or four parents. Could there be a threefold sexual mule? 6. Power of attraction. Aptitude to be attracted. Chemical combinations by single attraction. By double affinity. 7. Union of animated bodies with inanimate matter, as in swallowing food. In absorption by the lacteals. Vitality of the blood. Fibrils with nutritive appetencies. Molecules with nutritive propensities. 8. Fibrils with formative appetencies, and molecules with formative propensities secreted beneath the cuticle of trees, and coalesce. Hunger and love, thirst, suckling children, they reciprocally stimulate and embrace each other. 9. Great secret of nature. Formative or nutritive particles in the blood more than necessary. Secreted by numerous glands. Arranged under the cuticle of trees. Acquire new appetencies, and produce new parts. 10. In sexual generation they are secreted by two glands only. Those of the anther and pericarp unite in the matrix. 11. Without formative molecules as well as formative fibrils*

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there could be no mules, or any reſemblance to the mother. The new doctrine of threefold vegetable mules applied to animal generation. 12. *Concluſion.*

THE theory of Linneus in reſpect of the reproduction of vegetables maintains, that the internal medullary part muſt be joined with the external or cortical part of the plant for the purpoſe of producing a new one. If the medulla be ſo vigorous as to burſt through its containing veſſels, and thus mix with the cortical part, a bud is produced either on the branches or roots of vegetables; otherwiſe the medulla is extended, till it terminates in the piſtillum, or female part of the flower; and the cortical part is likewiſe elongated, till it terminates in the anthers, or male part of the flower; and then the fecundating duſt from the latter being joined to the prolific juices of the former, produces the ſeeds or new plants; at the ſame time the inner rind is extended into the corol or petal, and the outer bark into the calyx.

After the ſeeds are thus produced, the parent bud dies; and in this reſpect the buds bear a very great analogy to thoſe annual inſects, which change from their caterpillar or larva-forms, putting forth painted wings and organs of reproduction, and after depoſing their eggs ceaſe to exiſt. See the account of the vegetable kingdom by Linneus, prefixed to the ſyſtem of vegetables tranſlated by a botanical ſociety at Lichfield. Leigh and Sotheby, London.

However ſimple and ingenious the firſt part of this theory may appear, in which the medulla is ſuppoſed to extend itſelf, till it burſts the incloſing or cortical part, and joining with that produces a new bud; yet it ſeems too mechanical for a living organized ſyſtem; and ſo totally different from any thing we know of ſexual production either in animals or flowers, as not readily to ſatisfy a reaſoning mind.

Every new fluid or ſolid produced in the organic ſyſtem of vegetable or animal bodies is ſecreted from their blood, as the various fluids of bile, ſaliva, tears, in animals; and thoſe of gum, reſin, ſugar, in vegetables. Amongſt theſe are the juices which conſtitute the nutritious fluid of the amnios in the uterus of viviparous animals, or that of the albumen of the egg in oviparous ones. And laſty, the flavilla vitæ, the new ſpark of being, or living entity, is alſo ſecreted from the blood of male animals by adapted glands to be received into a proper nidus, and nouriſhed by the female.

I. LATERAL PROGENY.

1. As the leaf with its petiole, or foot-ſtalk, and its caudex down the bark of a tree, with its radicle beneath, conſtitutes an individual plant; and the bud in its boſom ſucceeds, and is evidently produced by it; it may be concluded from the ſtrongeſt analogy that this new progeny is ſecreted from a gland or glands of the parent; and that, as it adheres to the parent, it requires no female apparatus for its reception, nouriſhment, or oxygenation.

I was formerly induced to believe, that there was a communication of blood, or inoſculation of veſſels between the parent leaf, and the new bud in its boſom, as expreſſed in Zoonomia, Sect. XXXIX. 2. 2. and that this conſtituted the difference between paternal geſtation and maternal geſtation. But that the veſſels between the new bud and the parent leaf-bud do not inoſculate may be well ſeen by taking away the bark of the foot-ſtalk of a leaf, and of the new bud in its boſom; as the remains of the arteries of the late leaf, as well as the rudiment of the new bud, are ſeen to terminate in the alburnum, or to penetrate the pith, but without any apparent communication; and I therefore ſuſpect, that the embryon bud is not ſerved with vegetable blood from the veſſels of the parent, but that it acquires both nutriment and oxygenation much in the ſame manner as the chick in the egg. See Sect. III. 1. 5.

2. The condition of the chick in the egg differs from that of the fetus

fetus in the womb of viviparous animals in the whole of its nutriment being at firſt provided for it, which confiſts of the albumen, or white of the egg, which is contained in cells, and is of different degrees of confiſtency, that which is moſt fluid being firſt conſumed; whereas the liquor amnii, or nutriment of the fetus in utero, is gradually ſecreted by adapted glands from the blood of the mother, as it is wanted.

Another difference between the condition of the chick and of the fetus confiſts in the manner, by which their blood acquires its neceſſary oxygenation. In the fetus this is done by means of the placental veſſels, whoſe extremities are inſerted into the blood-veſſels of the uterus, and receive oxygen through their moiſt membranes from the paſſing currents of the mother's blood, as deſcribed in Zoonomia, Vol. I. Sect. XXXVIII. Whereas in the egg after a few days incubation a membrane is ſeen, which includes the albumen, and ſpreads the extremities of its fine blood-veſſels on the moiſt membrane, which covers the air at the broad end of the egg; which air is occaſionally renewed, as would appear by its being ſeen ſo eaſily to paſs through the ſhell, when an egg is covered with water in the exhauſted receiver of an air-pump.

The condition of the embryon bud, when the parent leaf-bud dies, I conceive to be ſimilar to that of the chick in the egg, when that is ſeparated from its parent. Each of them has at this time a reſervoir of nutriment provided for it; that of the chick conſiſts of the albumen, or white of the egg above mentioned; and that of the bud conſiſts of mucilage and ſugar, which are depoſited in the alburnum or ſap-wood, or in the roots of the plant. And ſecondly, I conceive that the extremities of a fine ſyſtem of veſſels belonging to the bud may terminate on the moiſt membrane, which covers the horizontal air-veſſels deſcribed in Sect. III. 2. 6. as thoſe on the chorion of the chick terminate on the air-bag of the egg, and thus acquire the neceſſary oxygenation of their vegetable blood.

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This analogy between the vegetable and animal fetus in refpect to their production, nourifhment, and oxygenation, is as forcible in fo obfcure a fubject, as it is curious; and may in large buds, as of the horfe-chefnut, be almoft feen by the naked eye. If with a penknife the remaining rudiment of the laft year's leaf, and of the new bud in its bofom, be cut away flice by flice, the feven ribs of the laft year's leaf will be feen to have arifen from the pith in feven diftinct points, making a curve; and the new bud to have been produced in their center, and to have pierced the alburnum and bark, and grown without the affiftance of a mother.

And laftly, by in part cutting, and in part tearing, the pith and alburnum from the bottom of a new leaf-ftalk of horfe-chefnut about the middle of May, an oval prominence may be feen in the internal part of the leaf-ftalk, which fills up a fpace between the veffels of the bottom of the leaf-ftalk and thofe of the new bud, and feems to connect them by its extremities, and to prefs on the pith beneath it. From this apparent gland I conjecture that the now living fibres, or animalcules, are probably fecreted, which form the new bud adhering to the pith, and nourifhed by the parent leaf; that thus a paternal progeny is produced without the affiftance of a mother.

3. This paternal offspring of vegetables in their buds and bulbs is attended with a very curious circumftance; and that is, that they exactly refemble their parents, as is obfervable in grafting fruit-trees, and in propagating flower-roots; whereas the feminal offspring of plants, being generated by two parents, and certainly fupplied with nutriment by the mother, is liable to perpetual variation. This alfo in the vegetable clafs diœcia, where the male flowers are produced on one tree, and the females on another, the buds of the male trees uniformly produce either male flowers, or other buds fimilar to themfelves; and the buds of the female trees either produce female flowers, or other buds fimilar to themfelves; whereas the feeds of thefe trees produce either male or female plants. See Sect. III. 2. 1.

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This ſimilarity of buds and bulbs to their parents is to be underſtood only to exiſt after the maturity of the plant, that is after it has produced a ſexual offspring in flowers and ſeeds; for a bulb, as of a tulip, and a bud of a fruit-tree, when firſt raiſed from their ſeeds, are very ſmall, but produce one or more improved bulbs, or improved buds annually, for ſome years; which differ from their parent bulbs or buds in the ſize, form, and colour of their leaves, till it arrives at its maturity, or acquires the power of generating a ſexual progeny; from whence it appears, that the leaf-buds of thoſe trees, and the leaf-bulbs of thoſe roots, which have acquired their puberty, if it may be ſo called; that is, their power of generating flowers, are a more perfect progeny than the ſeeds of thoſe plants, as theſe latter, when ſeparated from their parent either by tranſplantation or by ingrafting, can immediately produce ſeeds, or a ſexual progeny; but the buds from many ſeeds are ſome years before they can produce ſeeds. The ſame is probably true of many annual or biennial plants, as of wheat; which produce many ſucceſſive buds upon each other previous to the flower-bud, as appears by the joints of the ſtem; all which may be conſidered as individual plants growing on each other like the annual ſucceſſion of the buds of trees.

Another curious occurrence in this lateral production of vegetables by their buds has been lately publiſhed by Mr. Knight in the Phil. Tranſ. for the year 1795, who obſerves, that thoſe apple-trees, which have been continually propagated for above a century by ingrafting, are now become ſo diſeaſed by canker, or otherwiſe, that though the fruit continues of the ſame flavour, the trees are not worth propagating; as theſe grafts, though tranſplanted into other trees, he eſteems to be ſtill an elongation of the original tree, and muſt feel the effect of age like the tree they were taken from. If this idea ſhould prove true on further examination, there is reaſon to ſuſpect the ſame may occur in the too long propagation of plants from bulbs and wires, as potatoes and ſtrawberries, which may have occaſioned the curled tops of potatoes,

toes, and the black blight in the flowers of the hautbois ſtrawberry, which ſome have aſcribed to its only bearing male flowers; the cure of which muſt ariſe from our applying to other varieties more lately derived from a ſeminal offspring.

This degeneracy of trees or perennial herbaceous plants propagated by buds or root-ſcions is not I think to be aſcribed ſimply to the age of the original ſeedling-tree, becauſe each ſucceſſive generation of buds or bulbs are as diſtinct from the parent, as the generation by ſeeds. But as the lateral progeny of vegetables have no ſource of improvement after they have arrived at their maturity, but are liable like other plants and animals to injuries from food and climate, which injuries produce hereditary diſeaſes, it is to this circumſtance that their degeneracy ought rather to be aſcribed; whereas the ſexual progeny of vegetables are liable to improvement by the intermixture of the individuals of the ſame, or even of different ſpecies to counteract the effects of hereditary diſeaſes.

Another curious ſimilarity which buds bear to their parent tree is alſo obſerved by Mr. Knight, Phil. Tranſ. for 1795. Part II. p. 292. "Cuttings from ſeedling apple-trees of two years old were inſerted on ſtocks of twenty years old, and in a bearing ſtate; but theſe have now been grafted nine years; and, though they have been frequently tranſplanted to check their growth, they have not yet produced a ſingle bloſſom. I have ſince grafted ſome very old trees with cuttings from ſeedling apple-trees of five years old. Their growth has been extremely rapid, and there appears no probability that their time of producing fruit will be accelerated, or that their health will be injured by the great age of the ſtocks. A ſeedling apple-tree uſually bears fruit in thirteen or fourteen years; and I therefore conclude, that I have to wait for a bloſſom, till the trees, from which the grafts were taken, attain that age; though I have reaſon to believe from the form of their buds that they will be extremely prolific. Every cutting therefore taken from the apple, and probably from every other tree, will be affected by the ſtate of the parent ſtock. If that be too young to produce fruit, it will grow with vigour, but will not bloſſom; and if it be too old, it will immediately produce fruit, but will never make a healthy tree, and conſequently never anſwer the intention of the planter.

"The durability of the apple and pear I have long ſuſpected to be different in different varieties; but that none of either would vegetate with vigour much, if at all, beyond the life of the parent ſtock, provided that died from mere old age. The oak is much more long-lived in the north of Europe than with us, though the timber is leſs durable; the climate of this country, being colder than its native one, may in the ſame way add to the durability of the elm; which may poſſibly be further increaſed by its not producing ſeeds in this climate; as the life of many annuals may be increaſed to twice its natural period, if not more, by preventing their ſeeding."

It is obſerved above, that the firſt bulb of a tulip raiſed from ſeed produces a more perfect bulb annually for five or ſix years, and perhaps more than one leſs perfect ones, before it acquires the power of generating ſeeds. Now when this period arrives, if the ſeed-ſtem be pinched off, I ſuppoſe that the next year's bulb or bulbs will become more vigorous or luxuriant, and if this be continued for three or four years I ſuſpect the double flowers, which are perhaps owing to a more luxuriant growth, may be formed; and that in this, with ſuperfluous nouriſhment by manure, warmth, and moiſture, conſiſts the art of obtaining hyacinths, ranunculus, and ſometimes tulips, with ſuch wonderful multiplication of petals or nectaries. See Sect. XIX. 3. 1.

4. The analogy, which exiſts between this lateral production of vegetables and that of ſome tribes of inſects, is worth inveſtigation. 1. This paternal or lateral generation of plants, which conſtitutes the buds on the ſtems of trees, and the ſcions on their roots, which continue to adhere to them, are ſo far reſembled by the branching inſects, which form the corals or corallines; and by many other ſea-

animals, as the ſea anemonies, which are ſaid to adhere to the ſhores, or ſubmarine earth, by one extremity, while they pullulate, or ſpread out by the other into living ramifications of unmeaſurable lengths.

Thoſe who have attended to the habits of the polypus, which is found in the ſtagnant water of our ditches in July, affirm, that the young ones branch out from the ſide of the parent like the buds of trees; and after a time ſeparate themſelves from them. This is ſo analogous to the manner in which the buds of trees appear to be produced, that theſe polypi may be conſidered as all male animals, producing embryons, which require no mother to ſupply them with a nidus, or with nutriment and oxygenation.

Secondly, this paternal or lateral vegetable progeny is beautifully ſeen in the wires of knot-graſs, polygonum aviculare.; and in thoſe of ſtrawberries, fragaria veſca; and in the roots of potatoes. The lateral generation of theſe plants by wires, while each new plant is thus chained to its parent, and continues to put forth another and another, as the wire creeps onward on or beneath the ground, is exactly reſembled by the tape-worm, or tænia, ſo often found in the bowels, ſtretching itſelf in a chain quite from the ſtomach to the rectum. Linneus aſſerts, "that it grows old at one extremity, while it continues to generate young ones at the other, proceeding ad infinitum, like a root of graſs. The ſeparate joints are called gourd-worms, and propagate new joints like the parent without end, each joint being furniſhed with its proper mouth and organs of digeſtion." Syſtema Naturæ, vermes, tenia. In this animal there evidently appears a power of reproduction without any maternal apparatus for the purpoſe of ſupplying nutriment and oxygenation to the embryon, as it remains attached to its father till its maturity, and in this reſpect exactly reſembles the lateral generation of vegetables.

5. This ſubject of the lateral production of vegetables from male parents without the intervention of a female is further reſembled by the innumerable progeny of the aphis, which riſes from an egg in the

ſpring,

ſpring, as a vegetable riſes from a ſeed, and produces a viviparous offspring for many generations like the ſucceſſive buds of a ſeedling apple-tree, or of a ſeedling tulip; and then it generates both males and females, which copulate and depoſit eggs, like the anthers and ſtigmas of flowers, and their conſequent ſeeds; which at length appear on ſeedling apple-trees and on ſeedling tulips; as is further ſpoken of in Sect. IX. 2. 7. and XIV. 1. 6.

6. Whence I conclude, that in ſexual viviparous generation the new entity, or embryon, is ſecreted by the male, and received into a nidus prepared for it by the female, and nouriſhed by fluids ſecreted into the uterus, as they are required, which is probably owing to the ſtimulus of the fetus againſt the ſides of it; that in ſexual oviparous generation a reſervoir of nutriment is prepared, and incloſed in the egg, previous to the reception of the embryon, which is ſecreted by the male, and depoſited in this reſervor of nutriment; becauſe the fetus in theſe animals is to be ſeparated from the parent before its due maturity; and the egg, in which it is incloſed, may be conſidered as an uterus, or womb, ſeparated from the mother. And laſtly, that in paternal or male generation the new entity, or embryon, is as certainly ſecreted from a gland of the male, but probably remains in an adapted reſervoir belonging to this gland, correſpondent to the veſiculæ ſeminales of moſt viviparous animals, and that here it exiſts like the cicatricula in the egg, and has a reſervoir of nutriment prepared for it like that in the egg to ſupport it; when the paternal leaf-bud by its death is ſeparated from it in the autumn, as the egg is ſeparated from its living mother.

7. The production of buds in the axilla of every leaf may thus be eaſily conceived, as the new buds are furniſhed with their caudexes or bark-filaments over thoſe of their dead parents, which ſhoot out root-fibres beneath in the enſuing ſpring, and that I ſuppoſe both in deciduous plants and in evergreens; as in the latter alſo I believe the arent leaf-bud annually falls off, though not by the immediate in-

fluence of the cold of autumn. But how long a twig or ſcion of leaves, as in the vine or willow, ſucceed each other, ſome producing embryon buds in their boſoms before others become expanded, is not eaſy to underſtand; but the embryons of all theſe new leaves, though not of the buds in their boſoms, probably exiſted in the paternal womb, though in different degrees of maturity, which accords with the obſervations of ſome naturaliſts on the ſucceſſive generations of the volvox globator, which Linneus aſſerts to be diaphanous, and that it carries within itſelf ſons and grandſons to the fifth generation, but which are probably living fetuſes produced by the father, of different degrees of maturity, and to be detruded at different periods of time like the unimpregnated eggs of various ſizes, which are found in poultry. See Zoonomia, Vol. I. Sect. XXXIX. 2. and Linnei Syſtem. Naturæ. Vermes. Volvox.

In ſome trees however, as in the vine, vitis, and in many herbaceous plants, as in wheat, ſouthiſtle, teaſel, triticum, ſonchus, dypſacus, each ſucceſſive joint of the plant is evidently an individual vegetable being; becauſe the pith, which conſtitutes the brain or ſpinal marrow of each individual, terminates at every joint by a diviſion, as ſpoken of in Sect I. 8. whence in theſe vegetables every ſucceſſive joint appears to be produced by that beneath it; whereas where there is no diviſion of the pith, the twig ſeems to be ſimply an elongation of the caudex of the leaf-bud, like the wires of ſtrawberries and other creeping plants.

It ſhould nevertheleſs be added, that there are many hermaphrodite inſects, as ſhell-ſnails and dew-worms, which contain both male and female organs of generation; and as they are perpetually ſeen to copulate with each other, it is believed, that they can not impregnate themſelves. Now it may be conceived, that the buds of trees poſſeſs both male and female organs of generation, and that they can impregnate themſelves, and that thus the new buds might be termed an hermaphrodite offspring rather than a paternal one. This would however

however produce a confufion of terms, as the eggs of fnails and of worms, as mentioned above, are properly an hermaphrodite off-fpring.

Another circumftance occurs in this paternal generation, which differs from that of thofe hermaphrodite infects above alluded to, which is, that though in vegetables the new embryon is generally produced in the bofom of the leaf-ftalk, which is believed to be its parent; yet new buds are occafionally protruded from almoft any part of the bark, when the fummit of a branch is taken off, or the fide branches of a tree, fo as to admit light and air, and a fupply of more nutriment; whence it would feem, that though hermaphrodite infects poffefs but one male and one female apparatus for the production and reception of the new entity or embryon, yet that in paternal generation the prolific fluid is occafionally fecreted in any part of the caudex of each individual bud from its fummit on the branch of a tree to its termination in the root; and that wherever a proper nidus can be found, which is fupplied with nutriment, and expofed to light and air, that there the new embryon can adhere and grow; although this occurs moft conveniently, and thence moft frequently, in the bofom of the leaf-ftalk, where the prolific fluid is probably firft fecreted, and the nutriment moft copioufly fupplied from the vegetable blood newly oxygenated in the leaf. In this I fuppofe to confift the great difference between paternal and fexual generation; and that this mode of reproduction forms an exception to the general axiom of the great Harvey, "all things from eggs."

The exiftence of a power of generation in every part of the caudex of a vegetable bud from the fummit to the root is not only fhewn by the new buds, which grow on the trunks of trees, which were felled in the fpring, but alfo from a curious circumftance which occurs in ingrafted trees; which is, that whenever after many years any new buds or fcions grow from the ftock beneath the graft, it is always fimilar to the parent ftock, and not to the ingrafted fcion; which

fhews,

ſhews, that this new bud was generated in the old ſtock, and not that it was owing to an abſorption and depoſition of a prolific fluid ſecreted in any part of the ingrafted head. It muſt however be remembered, that the caudex of each bud extends from the leaf-ſtalk to the root, whether it be a ſimple caudex as in a ſeedling tree, or a compound one as in a grafted tree; and that the generation of new buds in perennial herbaceous plants exiſts in every part of the broad caudex on the root, as it does here in every part of the long caudex on the trunk. Nothing known in the animal world reſembles this univerſality of the generative faculty throughout almoſt the whole of an individual vegetable being, except the number of new polypi ſaid to ariſe at the ſame time from different parts of the ſame individual animal.

Wherever the new vegetable embryons are ſecreted, they alſo find a ſituation or uterus, where they can adhere and be nouriſhed to almoſt any number; which however is not unſupported by ſome analogy even in viviparous animals; as there have been many inſtances of extra-uterine fetuſes, which have attached or inſerted their veſſels into the peritoneum, or on the viſcera of the mother, in the ſame manner as they naturally attach or inſert them into the ſides of the true uterus. And in reſpect to the number of uteri produced we may recollect the number of eggs, and of fiſh-ſpawn, or frog-ſpawn, or of ſeeds, which may all be termed ſo many diſtinct uteri, as they contain every thing, which is found in the uteri of viviparous animals.

The aphis, and probably many other inſects, poſſeſs both the ſolitary and ſexual mode of propagation, as is poſſeſſed by moſt vegetables; but the polypus and tenia, and hydra ſtentorea, and volvox, appear only to be reproduced by the ſolitary or lateral generation; and it is probable that the truffle amongſt vegetables, and ſome ſubmarine plants, and others of the claſs cryptogomia, whoſe ſeeds have not been yet diſcovered, may ſtill be only propagated by the

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lateral mode of reproduction, as is well obferved in an ingenious work by a lady of very accurate botanic knowledge, called "Botanic Dialogues, defigned for the ufe of fchools," one volume octavo, Johnfon, London; but which may be ftrongly recommended to the adult in botany as containing much ufeful information agreeably imparted.

This curious fubject of lateral or folitary generation is well worthy more accurate inveftigation, as it is the fimpleft, and was probably the firft mode of reproduction which exifted; and if any accurate knowledge can ever be acquired of animal generation, it will poffibly occur from a more nice attention to the production of the buds and bulbs of vegetables! which is further fpoken of in Sect. IX. 2 and 3. At the fame time it muft be obferved, that the fexual reproduction is the chef d'ouvre, the mafter-piece of nature, as by the paternal or lateral reproduction the fame fpecies only are propagated ad infinitum; whereas by the fexual mode of reproduction a countlefs variety of animals are introduced into the world, and much pleafure is afforded to thofe, which already exift in it.

II. SEXUAL PROGENY.

1. We come now to the feminal mode of the production of vegetables, which originates from the congrefs of the male and female parts of flowers, and may be therefore termed the fexual or amatorial progeny of vegetation.

From the accurate experiments and obfervations of Spallanzani it appears, that in the Spartium Junceum, rufh-broom, the very minute feeds were difcerned in the pod at leaft twenty days before the flower is in full bloom; that is, twenty days before fecundation. At this time alfo the powder of the anthers was vifible, but glued faft to their fummits. The feeds however at this time, and for ten days after the bloffom had fallen off, appeared to confift of a gelatinous

8 fubftance.

ſubſtance. On the eleventh day after the falling of the bloſſom the ſeeds became heart ſhaped, with the baſis attached by an appendage to the pod, and a white point at the apex; this white point was on preſſure found to be a cavity including a drop of liquor.

On the twenty-fifth day the cavity, which at firſt appeared at the apex, was much enlarged, and ſtill full of liquor; it alſo contained a very ſmall ſemi-tranſparent body of a yellowiſh colour, gelatinous, and fixed by its two oppoſite ends to the ſides of the cavity.

In a month the ſeed was much enlarged, and its ſhape changed from a heart to a kidney; the little body contained in the cavity was increaſed in bulk, and was leſs tranſparent, and gelatinous, but there yet appeared no organization.

On the fortieth day the cavity now grown larger was quite filled with the body, which was covered with a thin membrane; after this membrane was removed, the body appeared of a bright green, and was eaſily divided by the point of a needle into two portions, which manifeſtly formed the two lobes; and within theſe attached to the lower part the exceedingly ſmall plantule was eaſily perceived.

The foregoing obſervations evince, 1. That the ſeeds exiſt in the ovarium many days before fecundation. 2. That they remain for ſome time ſolid, and then a cavity containing a liquid is formed in them. 3. That after fecundation a body begins to appear within the cavity fixed by two points to the ſides, which in proceſs of time proves to be two lobes containing a plantule. 4. That the ripe ſeed conſiſts of two lobes adhering to a plantule, and ſurrounded by a thin membrane, which is itſelf covered with a huſk or cuticle. Spallanzani's Diſſertations, Vol. II. p. 253.

The analogy between ſeeds and eggs has long been obſerved, and is confirmed by the mode of their production. The egg is known to be formed within the hen long before its impregnation. C. F. Wolf aſſerts, that the yolk of the egg is nouriſhed by the veſſels of the mother, and that it has from thoſe its arterial and venous branches; but

but that after impregnation theſe veſſels gradually become impervious and obliterated; and that new ones are produced from the fetus, and diſperſed into the yolk. Haller's Phyſiol. Tom. VIII. p. 94. The young ſeed after fecundation I ſuppoſe is nouriſhed in a ſimilar manner from the gelatinous liquor, which is previouſly depoſited for that purpoſe; the uterus of the plant producing or ſecreting it into a reſervoir or amnios, in which the embryon is lodged; and that the young embryon is furniſhed with veſſels to abſorb a part of it, as in the very early ſtate of the embryon in the egg.

Another curious analogy ſeems to exiſt between the embryon of the ſeed and of the egg in their mode of ſuſpenſion. The cicatricula of the egg reſts on the yolk, which is ſuſpended by two points, called chalazæ, ſomewhat above its center of gravity; whence, however the egg is moved, this embryon is always kept upwards, probably the better to receive the warmth of the mother during incubation. The ſeed-embryon ſeems to be ſupported in the ſame manner by the above relation of Spallanzani by two points, and may thus receive a greater warmth from the ſummer ſun.

2. The ſeeds are thus produced in their unimpregnated ſtate in the vegetable uterus, and nouriſhed by the flower-bud, which was formed in the deciduous trees of this climate during the preceding ſummer, and which now puts forth the bractes, or floral-leaves, for the oxygenation of its blood; and protrudes its roots and abſorbents into the ground from the lower part of its caudex, for the purpoſe of acquiring nouriſhment; and on the ſummit of this ſexual apparatus are at the ſame time produced the corol and nectaries of the flower, with the ſtamens, and ſtigmas, which are evidently deſigned to give fecundation to the vegetable ſeeds, or eggs, previouſly depoſited in the pericarp or uterus; becauſe, as ſoon as theſe are impregnated, the corol and nectaries, with the ſtamens, and ſtigmas, fall off and diſappear.

The anthers have been proved by many experiments to be neceſſary to the fecundation of the vegetable ſeeds by the farina, or duſt,

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which they difperfe, and which adheres to the moift ftigma on the fummit of the ftyle or pericarp. The amatorial attachment between thefe ftigmas and the anthers on the fummits of the ftamens has attracted the notice of all botanifts. In many flowers the anthers or males bend into contact with the ftigmas or females, as in kalmia, fritillaria perfica, parnaffia, cactus, and ciftus. In the kalmia the ten ftamens lie round the piftil, like the radii of a wheel, and each anther is concealed in a nich of the corol to protect it from cold and moifture; thefe anthers rife feparately from their niches, and approach the ftigma of the piftil for a time, and then recede to their former fituations. In the fritillaria perfica the fix ftamens are of equal lengths, and the anthers lie at a diftance from the piftil; of thefe three alternate ones approach firft, and furround the female; and when thefe decline, the other three approach; and in parnaffia the males alternately approach and recede from the female; and laftly in the moft beautiful flowers of cactus grandiflorus, and of ciftus labdaniferus, where the males are very numerous, fome of them are perpetually bent into contact with the female; and as they recede, others advance.

In other flowers the females bend into contact with the males, as in nigella, epilobium, fpartium, collinfonia. In nigella, devil in the bufh, the females are very tall compared to the males, and bending down over them in a circle, give the flower fome refemblance to a regal crown. The female of the epilobium anguftifolium, willow-herb, bends down amongft the males for feveral days, and becomes upright again when impregnated. In the fpartium fcoparium, common broom, the males or ftamens are in two fets, one fet rifing a quarter of an inch above the other. The upper fet does not arrive at their maturity fo foon as the lower; and the ftigma, or head of the female, is produced amongft the upper or immature fet. But as foon as the piftil grows tall enough to burft open the keel-leaf, or head of the flower, it bends itfelf round in an inftant like a French horn, and

and inſerts its head, or ſtigma, amongſt the lower or mature ſet of males. The piſtil or female then continues to grow in length; and in a few days the ſtigma arrives again amongſt the upper ſet, by the time they become mature. This wonderful contrivance is readily ſeen by opening the keel-leaf of the flowers of broom, before they burſt ſpontaneouſly. And laſtly, in the collinſonia the two males widely diverging from each other, the female bends herſelf into contact firſt with one of them; and after a day or two leaves this, and applies herſelf to the other; the anther of which was not mature ſo ſoon as the former. See Sect. VIII. 8. of this work.

Dr. Peſchier of Geneva thinks, he has diſcountenanced this idea of amatorial ſenſibility of vegetables by two experiments, which are related in Journal de Phyſique de Lametherie, T. II. p. 343. One of theſe conſiſted of his tying down the ſtigma of epilobium anguſtifolium, and yet in due time the anthers burſt and ſhed their pollen, and thus committed a kind of vegetable Onaniſm; and alſo that he caſtrated the ſtamens of this flower, and yet the ſtigma opened and aroſe, as if the anthers had been preſent. The other experiment conſiſted in his confining a branch of barbery, berberis, in a glaſs, and ſubjecting the ſtamina of the flowers to the vapour of nitrous acid, which by this ſtimulus aroſe from their petals to the ſtigma, and after a few minutes again retired to their petals. Both theſe experiments rather ſeem to confirm than to enfeeble the analogy between plants and animals; as the amatorial motions of theſe flowers were thus produced by internal or external ſtimuli, as in the healthy or diſeaſed ſtates of animals.

Another mode, in which the prolific duſt is diſperſed, is by the burſting of the anther, and its conſequent diffuſion in air, either ſo as to make a cloud near the females, which exiſt in the ſame flower, or on the ſame plant, which is the moſt uſual manner; or by its being carried by the winds to a greater diſtance, as in the flowers of the claſs monœcia, or one houſe. So in urtica, nettle, the male

flowers

flowers are ſeparate from the female, and the anthers are ſeen in fair weather to burſt with force, and to diſcharge their duſt, which hovers about the plant like a cloud.

In plants of the claſs diœcia, or two houſes, the fecundating farina is carried to the diſtance of many miles by the winds, as has been proved by the impregnation of ſome female date trees, which were at a great diſtance from the male ones. And the male flowers themſelves of valliſneria are carried many miles down the rivers, which it inhabits, to the female ones. This plant has its roots at the bottom of the Rhone; the flowers of the female plant float on the ſurface of the water, and are furniſhed with an elaſtic ſpiral ſtalk, which extends or contracts, as the water riſes and falls. The flowers of the male plant are produced under water, and as ſoon as their farina, or duſt, is mature, they detach themſelves from the plant, and riſe to the ſurface, continue to flouriſh, and are wafted by the air, or borne by the currents, to the female flowers. In this reſembling thoſe tribes of inſects, where the males at certain ſeaſons acquire wings, but not the females, as ants, coccus, lampyris, phalæna, brumata, lichanella. See valliſneria in the Families of Plants, tranſlated from Linneus. Johnſon, London.

The plants, which grow in the air, are frequently injured in wet ſeaſons by the moiſture occaſioning the cells of the anthers, which contain the fecundating farina, to burſt, and to ſhed it on the ground. To which a ſcarcity of the quantity of wheat, or an imperfection of its fecundating quality, and the uſtilago, or ſmut, have rationally been aſcribed, as its anthers are expoſed on long filaments to the weather. On this account many flowers cloſe their corols before rain, and the aquatic plants of rivers perform their impregnations in the air. But M. Bonnet remarks another method of the diſperſion of the fecundating influence of ſome marine plants, in which the male organ does not project a fine powder, but a liquor, which forms a perceptible cloud in the water; and adds, that the male ſalamander darts his ſemen into the water, where it forms a whitiſh cloud, which is afterwards received by the ſwollen anus of the female, and ſhe becomes impregnated. Nor is this vegetable impregnation in water unanalogous to other animal impregnations, as the ſpawn of frogs and of fiſh is delivered from the female before it is fecundated; and its fecundation is ſeen to ſucceed in water; and Spallanzani found, that the ſeminal fluid even of dogs, as well as of frogs, retained its prolific quality when diluted with much water. Bonnet's Œuvres Philoſ. in a letter to Spallanzani.

3. The other parts, which riſe on the edge of the pericarp, and expand themſelves before the impregnation of the ſeed, are the corol and nectaries. The former of theſe has been ſhewn to be a reſpiratory organ for the purpoſe of oxygenating the blood to a greater degree than in the green foliage, as it is there expoſed to the air beneath a finer pellicle, and acquires variety of colours. See Sect. IV. 5. 1. to which may be added, that as the corol in helleborus niger, Chriſtmas roſe, changes after the fecundation of the ſeed into a calyx, loſing its white colour, and becoming green. So in many flowers the calyx falls off along with the corol; in theſe it ſhould be eſteemed a part of or appendage to the corol; whereas thoſe calyxes, which are permanent after the corol falls off, are properly parts of the pericarp or vegetable uterus.

4. The nectary, or honey-cup, is evidently an appendage to the corol, and is the reſervoir of the honey, which is ſecreted by an appropriate gland from the blood after its oxygenation in the corol, as mentioned in Sect. IV. 5. 5. and is abſorbed for nutriment by the ſexual parts of the flower. This purpoſe however has as yet eſcaped the reſearches of philoſophical botaniſts. M. Pontedera believes it deſigned to lubricate the vegetable uterus. (Antholog. p. 49.) Others have ſuppoſed, that the honey, when reabſorbed, might ſerve the purpoſe of the liquor amnii, or white of an egg, as a nutriment for the young embryon, or fecundated ſeed, in its early ſtate of exiſtence.

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But as the nectary is found equally general in male flowers as in female ones, and as the young embryon, or feed, grows before the petals and nectary are expanded, and after they fall off; thefe feem to be infurmountable objections to both the above-mentioned opinions.

In many tribes of infects, as the filk-worm, and perhaps in all the moths and butterflies, the male and female parents die, as foon as the eggs are impregnated and excluded, the eggs remaining to be perfected and hatched at fome future time. The fame thing happens to the male and female parts of flowers; the anthers and filaments, which conftitute the male parts of the flower, and the ftigma and ftyle, which conftitute the fenfitive or amatorial organ of the female part of the flower, fall off and die, as foon as the feeds are impregnated, and along with thefe the petals and nectary. Now the moths and butterflies above mentioned, as foon as they acquire the paffion and the apparatus for the reproduction of their fpecies, lofe the power of feeding upon leaves, as they did before, and become nourifhed by what?—by honey alone.

Hence we acquire a ftrong analogy for the ufe of the nectary, or fecretion of honey, in the vegetable economy; which is, that the male parts of flowers, and the female parts, as foon as they leave their fetus-ftate, expanding their petals, (which conftitute their lungs) become fenfible to the paffion, and gain the apparatus, for the reproduction of their fpecies; and are fed and nourifhed with honey like the infects above defcribed; and that hence the nectary begins its office of producing honey, and dies or ceafes to produce honey, at the fame time with the birth and death of the anthers and the ftigmas; which, whether exifting in the fame or in different flowers, are feparate and diftinct animated beings.

Previous to this time the anthers with their filaments, and the ftigmas with their ftyles, are in their fetus-ftate fuftained in fome plants by their umbilical veffels, like the unexpanded leaf-buds, as in colchicum autumnale, and daphne mezereon; and in other plants by the bractes, or floral-leaves, as in rhubarb, which are expanded long before the opening of the flower; the feeds at the fame time exifting in the vegetable womb yet unimpregnated, and the duft yet unripe in the cells of the anthers. After this period the petals become expanded, which have been fhewn to conftitute the lungs of the flower; the umbilical veffels, which before nourifhed the anthers and the ftigmas, coalefce, or ceafe to nourifh them; and they acquire blood more oxygenated by the air, obtain the paffion and power of reproduction, are fenfible to heat, and light, and moifture, and to mechanic ftimulus, and become in reality infects fed with honey; fimilar in every refpect except that all of them yet known but the male flowers of vallifneria, continue attached to the plant, on which they are produced.

So water infects, as the gnat, and amphibious animals, as the tadpole, acquire new aerial lungs, when they leave their infant ftate for that of puberty. And the numerous tribes of caterpillars are fed upon the common juices of vegetables found in their leaves, till they acquire the organs of reproduction; and then they feed on honey, all I believe except the filk-worm, which in this country takes no nourifhment after it becomes a butterfly. And the larva or maggot of the bee, according to the obfervations of Mr. Hunter, is fed with raw vegetable matter, called bee-bread, which is collected from the anthers of flowers, and laid up in cells for that purpofe, till the maggot becomes a winged bee, acquires greater fenfibility, and is fed with honey. Phil. Tranf. 1792.

Laftly, though the filaments and ftyle, as well as the corolla and nectary, belong to the fexual organs of vegetables; yet it is the anthers alone of the ftamina, and ftigmas alone of the piftilla, which poffefs the power, and I fuppofe the paffion of reproduction, as appears from the mutilated filaments of many flowers, as of curcuma, of linum or flax of this country, of gratiola, and hemlock-leaved ge-

ranium,

ranium, which have half their ftamina unterminated by anthers, and in confequence produce no prolific farina. And fecondly, from the florets, which form the rays of the flowers of the order fruftraneous polygamy of the clafs fyngenefia, as the fun-flower, which are furnifhed with a ftyle only, and no ftigma, and are thence barren. There is alfo a ftyle without a ftigma in the whole order of diœcia gynandria, the male flowers of which are thence barren, and fhews the neceffity of the exiftence of the ftigma to the fecundation of the vegetable uterus, probably owing to its amatorial action in conveying the living principle to the included feeds like the fallopian tubes of the animal womb.

5. The feeds are produced in the pericarp, and at firft acquire nutriment by the umbilical veffels previous to their fecundation, like the unexpanded leaf-buds; and then by the caudex down the bark with its radicles, which is oxygenated by the bractes, or floral-leaves, as foon as thefe are expanded, they afterwards become in one day impregnated in fome flowers, as in the oenothera, cactus grandiflorus, and ciftus; and the corol or petals, with the ftamens and ftigmas, and nectaries, wither and fall off. In other flowers many days elapfe before the various cells of feeds are fecundated, and thefe more animated parts of fexual reproduction perifh. But in all cafes the feeds remain in the pericarp or uterus after-fecundation as before it, except in thofe plants, which are called proliferus, as the polygonum viviparum, and magical onions, which immediately begin to vegetate; in all other plants the feed either fleeps till the enfuing fpring, as in the colchicum and hamamelis; or they continue to grow to maturity, and to be nourifhed in the pericarp by the blood of the parent flower-bud, which is oxygenated in the bractes or floral-leaves, till they become perfected like eggs, and fall on the ground, or are otherwife difperfed, for the purpofe of taking root in the earth.

Whence it appears, that in the fexual reproduction of vegetables the amatorial organ is diftinct from the uterus, as is probably the cafe

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in animals; which in female quadrupeds would feem to fleep after impregnation during the time of geftation and lactefcence, and afterwards to revive; whereas this amatorial organ in vegetable flowers perifhes, when the uterus is impregnated, along with the male organs, neither of which are any longer of ufe in thefe annual beings.

The various methods, which nature has employed for the difperfion of feeds, are worth the attention of the farmer and gardener, both for the purpofe of preventing the growth of noxious feeds, and of collecting the profitable ones. The pericarp of fome plants burfts with fudden violence, when the feed is mature, and difperfes it to confiderable diftance; as that of wood-forrel, oxalis acetocalla; and of impatiens, touch me not. The feeds of many plants of the clafs fyngenefia are furnifhed with a plume, by which admirable mechanifm they are diffeminated by the winds far from their parent ftem, and look like a fhuttlecock, as they fly. Other feeds are diffeminated by animals; of thefe fome attach themfelves to their hair or feathers by a gluten, as mifletoe; others by hooks, as clivers, galium aperine; burdock, arctium lappa; hound's-tongue, cynogloffum. Others are fwallowed whole for the fake of the fruit, and voided uninjured, as the hawthorn, cratægus, juniper, and fome graffes. And the feeds of aquatic plants, and of thofe which grow on the banks of rivers, are carried many miles by the currents into which they fall.

Other feeds are feparated from each other, and difperfed by the twifting of the awn at the fummit of them, when moiftened by rain, as a black oat, avena fatua, with hairy awns, which feems to crawl like an infect when moiftened; geranium alfo, and barley; and as this happens in wet weather, the moift ground is then fit to receive and nourifh them. The awns of the geranium have been ufed as hygrometers by fticking the bafe of the feed into a cork for a pedeftal; and marking divifions on a paper circle beneath it; and the awn of barley is furnifhed with ftiff points, which, like the teeth of a faw, are all turned towards one end of it; as this long awn lies upon the ground, it extends itſelf in the moiſt air of night, and puſhes forward the barley-corn, which it adheres to; in the day it ſhortens as it dries; and as theſe points prevent it from receding, it draws up its pointed end; and thus, creeping like a worm, will travel many feet from the parent ſtem; and may thus be uſed as a travelling hygrometer, when laid on a cloth on the floor, like the automaton of Mr. Edgeworth, deſcribed in Botanic Garden, article Impatiens, Vol. II.

6. The formation of the organs for ſexual generation, in contradiſtinction to thoſe for lateral generation, in vegetables, and in ſome animals, as the polypus, the tænia, and the volvox, ſeems the chef d'œuvre, the maſter-piece of nature, as appears from many flying inſects, as moths and butterflies, which ſeem to undergo a general change of their forms ſolely for the purpoſe of ſexual reproduction; and in all other animals theſe organs are not complete till the maturity of the creature; whereas the lateral generation commences with the infancy of the germ or bud, as on the roots of young herbs, and on the ſtems of infant trees.

There ſeems nevertheleſs to be one circumſtance, in which the ſolitary generation of the buds of plants, when the plants are at their maturity, is ſuperior to the ſexual generation by ſeeds. This conſiſts in the progeny of the former being more perfect than that of the latter, in reſpect to the power of the reproduction of their ſpecies. Thus in many plants, as in tulips and apple-trees, the young vegetable from the ſeed produces other bulbs, or buds, for ſome years, which ſeem annually to improve, till at length they acquire a puberty, if it may be ſo called, and become furniſhed with ſexual organs for the purpoſe of ſeminal reproduction; whereas the leaf-buds, or leaf-bulbs, of the apple-tree and tulip during their firſt years produce other leaf-buds, or leaf-bulbs, rather more perfect than their parents; and when theſe bulbs, and buds, arrive at their puberty, or maturity, ſo as ~~to be~~ capable of ſexual generation, their new bulbs and new buds alſo, if taken from their dying parents, and tranſplanted or ingrafted, or left adhering to them, are immediately capable of producing flowers, and a consequent seminal progeny.

As the progeny by lateral generation so exactly resembles the parent stock, it follows, that though any new variety, or improvement, may be thus continued for a century or two, as in grafted fruit-trees, yet that no new variety or improvement can be obtained by this mode of generation; though some hereditary diseases, as the canker, are believed to arise in ingrafted trees, which have long been propagated by lateral generation, as explained in No. 1. 3. of this Section.

But from the sexual, or amatorial, generation of plants new varieties, or improvements, are frequently obtained; as many of the young plants from seeds are dissimilar to the parent, and some of them superior to the parent in the qualities we wish to possess; which is another proof that the anthers and stigmas of plants are animated beings, different from the green foliage of the tree on which they grow; as they produce varieties in the form of their offspring like sexual animals, which buds do not.

Besides the production of different, and sometimes more excellent, varieties in the species of vegetables from seeds, another advantage occurs from sexual generation, which is the production of new species of plants, or mules, by shedding the fecundating dust of some flowers on the stigmas of others of a different species, though generally of the same genus.

A mule cabbage is described in the Bath Agriculture, Vol. I. Art. 4, which is said to fatten a beast six weeks sooner than turneps. It is there said, "that the sort of cabbage principally raised is the tallow-loaf or drum-head cabbage; but it being too tender to bear sharp frost, I planted some of this sort and the common purple-cabbage used for pickling, (it being the hardiest I am acquainted with) alternately; and when the seed-pods were perfectly formed, I cut down the purple, and left the other for seed. This had the desired effect, and produced a mixt stock of a deep green colour with purple

 veins,

veins, retaining the ſize of the drum head, and acquiring the hardineſs of the purple."

In another curious paper of the Bath Society, Vol. V. p. 38, Mr. Wimpey relates, that he planted a field with garden-beans in rows about three feet aſunder in the following order, mazagan, white-bloſſom, long-podded, Sandwich-toker, and Windſor-beans. The mazagan and white-bloſſom were thraſhed firſt, when to his great ſurpriſe he found many new ſpecies of beans; thoſe from the mazagan were mottled black and white; the white-bloſſoms were brown and yellow inſtead of their natural black; and they were both much larger than uſual. See Sect. XVI. 4. of this work.

There is an apple deſcribed in Bradley's work, which is ſaid to have one ſide of it a ſweet fruit, which boils ſoft, and the other ſide a ſour fruit, which boils hard. This Mr. Bradley ſo long ago as the year 1721 ingeniouſly aſcribes to the farina of one of theſe apples impregnating the other; which would ſeem the more probable, if we conſider, that each diviſion of an apple is a ſeparate womb, and may therefore have a ſeparate impregnation, like puppies of different kinds in one litter. The ſame is ſaid to have occurred in oranges and lemons, and grapes of different colours.

Vegetable mules are ſaid to be numerous, and, like the mules of the animal kingdom, not always to continue their ſpecies by ſeed. There is an account of a curious mule from the antirrhinum linaria, toad-flax, in the Amœnit. Academ. V. I. No. 3. and many hybrid plants are deſcribed in No. 32. The urtica alienata is an evergreen plant, which appears to be a nettle from the male flowers, and a pellitory (parietaria) from the female ones and the fruit, and is hence between both. Murray, Syſt. Veg. Amonſt the Engliſh indigenous plants, the veronica hybryda, mule ſpeedwell, is ſuppoſed to have originated from the officinal one, and the ſpiked one; and the Sibthorpia Europæa to have for its parents the golden ſaxifrage and marſh pennywort. Pulteney's View of Linneus, p. 253.

There

There is another vegetable fact publifhed by M. Koelruter, which he calls " a complete metamorphofis of one natural fpecies of plants into another;" which fhews, that in feeds as well as in buds, the embryon proceeds from the male parent, though the form of the fubfequent mature plant is in part dependent on the female. M. Koelruter impregnated a ftigma of the nicotiana ruftica with the farina of the nicotiana paniculata, and obtained prolific feeds from it. With the plants, which fprung from thefe feeds, he repeated the experiment, impregnating their piftilla with the farina of the nicotiana paniculata. As the mule plants, which he thus produced, were prolific, he continued to impregnate them for many generations with the farina of the nicotiana paniculata, and they became more and more like the male parent, till he at length obtained fix plants in every refpect perfectly fimilar to the nicotiana paniculata, and in no refpect refembling their female parent the nicotiana ruftica. Blumenback on Generation.

Mr. Graberg, Mr. Schreber, and Mr. Ramftrom, feem of opinion, that the internal ftructure or parts of fructification in mule plants refemble the female parent; but that the habit or external ftructure refembles the male parent. See treatifes under the above names in Vol. VI. Amœnit. Academic.

7. Something fimilar to this feems to obtain in mixing the breeds of the fame fpecies of animals, and in animal mules, which may be worth the attention of the grazier. The mule produced from a horfe and a fhe afs refembles the horfe externally with his ears, mane, and tail; but with the nature, or manners of an afs. But the hinnus, or creature produced from a male afs and a mare, refembles the father externally in ftature, afh-colour, and the black crofs on his fhoulders, but with the nature or manners of a horfe. The breed from Spanifh rams and Swedifh ewes refembled the Spanifh fheep in wool, ftature, and external form; but was as hardy as the Swedifh fheep; and the contrary occurred in the breeds which were produced from Swedifh

rams

rams and Spaniſh ewes. The offspring from the male goat of Angora and the Swediſh female goat had long ſoft camel's hair; but that from the male Swediſh goat, and the female one of Angora, had no improvement of their wool. An Engliſh ram without horns, and a Swediſh horned ewe, produced ſheep without horns. Amœn. Acad. Vol. VI. p. 13.

8. From theſe circumſtances it appears, that not only new varieties may be procured from the ſeminal offspring of plants; where thoſe from the lateral offspring become diſeaſed by age, as the cankered apple-grafts, and perhaps the curled potatoes, and barren ſtrawberries; but that more curious or uſeful fruits or flowers may be obtained by ſhedding the farina of ſome valuable plant on the ſtigma of another variety of the ſame ſpecies, as of two different but equally excellent apple-trees, or tulip-flowers, hyacinths, anemonies, and geraniums. And thirdly, that mules may be produced by a mixture of different ſpecies of plants, and perhaps of different genera; as of pines and melons; grapes and gooſeberries; oranges and apples; apricots and nectarines; nuts and acorns; which may be afterwards propagated by the lateral progeny, if not by the ſeminal one.

The facility of generating vegetable mules ſeems forcibly to have ſtruck the great Linneus; who in the preface to his natural orders of plants at the end of his Genera Plantarum thinks, that about ſixty vegetables were at firſt created correſponding with his natural orders. That a mixture of theſe orders amongſt themſelves produced the genera; that a mixture of the genera amongſt themſelves produced the ſpecies; and that a mixture of the ſpecies produced the varieties, which he believes to accord with the general progreſs of nature "*from ſimpler things to the more compound.*"

In the ſame manner it may be ſuppoſed, that many of the preſent ſpecies of animals were originally mules produced by a mixture of animals of different genera; and that all ſuch mules, as had perfect organs of reproduction, continued their ſpecies. But as theſe organs ſeem feem to be the chef d'œuvre of nature, as above remarked, they often become imperfect in the generation of mules, and the fpecies then becomes extinct; as it could not be propagated by fexual generation, it is poffible, that many new kinds of mules, which might be ufeful for labour, or by their milk or wool, or for food, might ftill be produced by the method of Spallanzani; who diluted the feminal fluid of a dog with much warm water, and by injecting it fecundated a bitch, and produced puppies like the dog.

Thus new animal combinations might poffibly be generated numerous as the fabled monfters of antiquity; as between the ram and the female goat; the ftag and the cow; the horfe and the doe; the bull and the mare; boar and bitch; dog and fow. And fecondly, as Spallanzani diluted the feminal fluid of a male frog with water, and fecundated fome female fpawn with it, and produced perfect tadpoles, there is reafon to conclude, that new combinations of fifh might thus be generated, and people our rivers with aquatic monfters. And laftly, that it is not impoffible, as fome philofopher has already fuppofed, if Spallanzani fhould continue his experiments, that fome beautiful productions might be generated between the vegetable and animal kingdoms, like the eaftern fable of the rofe and nightingale, and which might be propagated by lateral or paternal, though not by fexual or feminal generation.

The claffic reader will here be reminded of the metamorphofes of Ovid, of gods turned into bulls and fwans, men into frogs and partridges, ladies into trees and flowers, of fphinxes, griffins, dragons, mermaids, centaurs, and minataurs; Pafiphae and her bull; Leda and her fwan; Arethufa and her fifh-god Alpheus, and conclude that mules in early times were more frequent than at prefent, which occafioned the poets and the priefts of antiquity to invent fo many fabulous monfters, and impofe them on the credulity of mankind.

III. VEGETABLE GENERATION.

1. The intelligent reader is become, I hope, by this time ſo much intereſted in the further inveſtigation of the circumſtances attending the lateral and ſexual generation of vegetables, that he will not be diſpleaſed with the continuance of the ſubject for a few more pages, ſo agreeable from its novelty, and ſo important from its future application to animal reproduction.

If a ſcion of a nonpareil apple be ingrafted on a crab-ſtock, and a golden pippin be ingrafted on the nonpareil, what happens? The caudex of the bud of the golden pippin conſiſts of its proper abſorbent veſſels, arteries, and veins, till it reaches down to the nonpareil-ſtock; and then the continuation of its caudex downwards conſiſts of veſſels ſimilar to thoſe of the nonpareil; when its caudex deſcends ſtill lower, it conſiſts of veſſels ſimilar to thoſe of the crab-ſtock.

The truth of this is ſhewn by two circumſtances; firſt, becauſe the lower parts of this compound tree will occaſionally put forth buds ſimilar to the original ſtock. And ſecondly, becauſe in ſome ingrafted trees, where a quick-growing ſcion has been inſerted into a ſtock of ſlower growth, as is often ſeen in old cherry-trees, the upper part of the trunk of the tree has become of almoſt double the diameter of the lower part; both which occurrences ſhew, that the lower part of the trunk of the tree continues to be of the ſame kind, though it muſt have been ſo repeatedly covered over with new circles of wood, bark, and cuticle.

Now as the caudex of each bud, which paſſes the whole length of the trunk of the tree, and forms a communication from the upper part, or plumula, to the lower part, or radicle, muſt conſiſt in theſe doubly ingrafted trees of three different kinds of caudexes, reſembling thoſe of the different ſtocks or ſcions; we acquire a knowledge of what may be termed a lateral or paternal mule, in contradiſtinction to a ſexual mule. For as in theſe trees thus combined by ingraftment every bud has the upper parts of its caudex that of a golden pippin, the middle part of it that of a nonpareil, of the lower part of it that of a crab; if theſe caudexes, which conſtitute the filaments of the bark, could be ſeparated intire from the tree with their plumules and radicles, they would exhibit ſo many lateral or paternal mules, conſiſting of the connected parts of their three parents; the plumula belonging to the upper parent, and the radicle to the lower one, and the triple caudex to them all.

A ſeparation of theſe buds from the parent plant is ſaid to have been obſerved by Mr. Blumenback in the conferva fontinalis, a vegetable which conſiſts of ſmall ſhort ſlender threads, which grow in our fountains, and fix their roots in the mud. He obſerved by magnifying glaſſes, that the extremities of the threads ſwell, and from ſmall tubera, or heads, which gradually ſeparate from the parent threads, attach themſelves to the ground, and become perfect vegetables; the whole progreſs of their formation can be obſerved in forty-eight hours. Obſervations on Plants, by Von Uſlar, Creech, Edinb.

2. The lateral propagation of the polypus found in our ditches in July, but more particularly that of the hydra ſtentorea, is wonderfully analagous to the above idea of the lateral generation of vegetables. The hydra ſtentorea, according to the account of monſieur Trembley, multiplies itſelf by ſplitting lengthwiſe; and in twenty-four hours theſe diviſions, which adhere to a common pedicle, reſplit, and form four diſtinct animals. Theſe four in an equal time ſplit again, and thus double their number daily, till they acquire a figure ſomewhat reſembling a noſegay. The young animals afterwards ſeparate from the parent, attach themſelves to aquatic plants, and give riſe to new colonies.

Another curious animal fact is related by Blumenback in his treatiſe on generation, concerning the freſh water polypus. He cut two of them in half, which were of different colours, and applying the upper part of one to the lower part of the other, by means of a glafs-tube, and retaining them thus for fome time in contact with each other, the two divided extremities united, and became one animal.

The attentive reader has already anticipated me in applying thefe wonderful modes of lateral animal reproduction and conjunction to the lateral propagation and ingraftment of vegetables. The junction of the head-part of one polypus to the tail-part of another is exactly reprefented by the ingraftment of a fcion on the ftock of another tree. The plumula, or apex of each bud, with the upper part of its caudex, joins to the long caudex of the ftock, which paffing down the trunk terminates in the radicles of it. And if this compound vegetable could be feparated longitudinally from the other long filaments of the bark in its vicinity, like the fibres of the bark of the mulberry-tree prepared at Otaheite, or as the bark of hemp and flax are prepared in this country, as the young ones of the hydra ftentorea feparate from their parents, it might claim the name of a lateral or paternal mule, as above mentioned.

3. It hence appears, that every new bud of a tree, where two fcions have been inferted over each other on a ftock, if it could be feparated from the plume to the radicle, muft confift of three different kinds of caudex, and might therefore be called a triple lateral mule. And that hence it follows, that every part of this new triple caudex, muft have been feparated or fecreted laterally from the adjoining part of the trunk of the tree; and that it could not be formed, as I formerly believed, from the roots of the plume of the bud defcending from the upper part of the caudex of it to the earth. A circumftance of great importance in the inveftigation of the curious fubject of the lateral generation of vegetables, and of infects.

One might hence fufpect, that if Blumenback had attended to the propagation of the polypus, which he had compofed of two half polypi, that the young progeny might have poffeffed two colours refembling ſembling the compound parent, like the different caudexes of ingrafted trees; an experiment well worthy repeated obſervation.

4. Another animal fact ought alſo to be here mentioned, that many inſects, as common earth-worms as well as the polypus, are ſaid to poſſeſs ſo much life throughout a great part of their ſyſtem, that they may be cut into two or more pieces without deſtroying them, as each piece will acquire a new head, or a new tail, or both; and the inſect will thus become multiplied. How exactly this is reſembled by the long caudex of the buds of trees, which poſſeſs ſuch vegetable life from one extremity to the other, that when the head or plume is lopped off, it can produce a new plume; and when the lower part is cut off, it can produce new radicles; and may be thus wonderfully multiplied.

5. Hence we acquire ſome new and important ideas concerning the lateral generation of vegetables, and which may probably contribute to elucidate their ſexual generation. Theſe are, firſt, that the parts of the long caudex of each new bud of an ingrafted tree, and conſequently of all trees, are ſeparated or ſecreted from the correſpondent or adjoining parts of the long caudex of the laſt year's bud, which was its parent; and not that it conſiſts of the roots of each new bud ſhot down from the plumula or apex of it, as I formerly ſuppoſed; and that thoſe various molecules, or fibrils, ſecreted from the caudex of the laſt year's buds, adjoin and grow together beneath the cuticle of the trunk of the tree, the upper ones forming the plumula of the new bud, which is its leaf or lungs, to acquire oxygen from the atmoſphere; and the lower ones forming the radicles of it, which are abſorbent veſſels to acquire nutriment from the earth.

Secondly, that every part of the caudex of an ingrafted tree, and conſequently of all trees, can generate or produce a new bud, when the upper part of it is ſtrangulated with a wire or cut off, or otherwiſe when it is ſupplied more abundantly with nutriment, ventilation, and light. And that each of theſe new buds thus produced refembles that part of the ftock in compound trees, where it arifes. Thus in the triple tree above mentioned a bud from the upper part of the long caudexes, which form the filaments of the bark, would become a golden pippin branch; a bud from the middle part of them would become a nonpareil branch; and a bud from the lower part a crab branch.

Thirdly, another wonderful property of this lateral mule progeny of trees compounded by ingraftment confifts in this, that the new mule may confift of parts from three, or four, or many parents, when fo many different fcions are ingrafted on each other; whence a quef- tion may arife, whether a mixture of two kinds of anther-duft previ- ous to its application to the ftigma of flowers might not produce a threefold mule, partaking of the likenefs of both the males?

6. On this nice fubject of reproduction fo far removed from com- mon apprehenfion the patient reader will excufe a more prolix invef- tigation. The attraction of all matter to the centres of the planets, or of the fun, is termed gravitation; that of particular bodies to each other is generally called chemical affinity; to which the attractions belonging to electricity and magnetifm appear to be allied.

In thefe latter kinds of attraction two circumftances feem to be required; firft, the power to attract poffeffed by one of the bodies, and fecondly, the aptitude to be attracted poffeffed by the other. Thus when a magnet attracts iron, it may be faid to poffefs a fpecific tendency to unite with the iron; and the iron may be faid to poffefs a fpecific aptitude to be united with the magnet. The former appears to refide in the magnet, becaufe it can be deprived of its attractive power, which can alfo be reftored to it; and the iron appears to pof- fefs a fpecific aptitude to be united with the magnet, becaufe no other metal will approach it. In the fame manner a rubbed ftick of fealing-wax may be faid to poffefs a fpecific tendency to unite with a light ftraw, but not with a glafs bead. Here the ftraw feems to poffefs a fpecific aptitude to unite with the rubbed fealing-wax, becaufe many

many other bodies refuſe to do ſo, as glaſs, ſilk, air; and laſtly, the ſpecific attraction of the rubbed ſealing-wax can be withdrawn or reſtored; to which may be added, that ſome chemical combinations may ariſe from the ſingle attraction of one body, and the aptitude to be attracted of another; or they may be owing to reciprocal attractions of the two bodies, as in what is termed by the chemiſts double affinity, which is known to be ſo powerful as to ſeparate thoſe bodies, which are held together by the ſingle attraction probably of one of them to the other, which other poſſeſſes only an aptitude to be attracted by the former.

7. The above account of the tendencies to union by unorganized or inanimate matter is not given as a philoſophical analogy, but to facilitate our conception of the adjunctions or concretions obſervable in organized or animated bodies, which conſtitute their formation, their nutrition, and their growth. Theſe may be divided into two kinds; firſt the junction or union of animated bodies with inanimate matter, as when fruit or fleſh is ſwallowed into the ſtomach, and becomes abſorbed by the lacteals; and the ſecond, where living particles coaleſce or concrete together, as in the formation, nutrition, or conjunction of the parts of living animals.

In reſpect to the former, the animal parts, as the noſtrils and palate, poſſeſs an appetency, when ſtimulated by the ſcent and flavour of agreeable food, to unite themſelves with it; and the inanimate material poſſeſſes an aptitude to be thus united with the animal organ. The ſame occurs when the food is ſwallowed into the ſtomach; the mouths of the lacteal veſſels being agreeably ſtimulated poſſeſs an appetency to abſorb the particles of the digeſting maſs, which is in a ſituation of undergoing chemical changes, and poſſeſſes at ſome period of them an aptitude to be united with the mouths of the abſorbent lacteals.

But when theſe abſorbed particles of inanimate matter have been circulated in the blood, they ſeem gradually to obtain a kind of vi-

 tality;

tality; whence Mr. John Hunter, and I believe ſome ancient philoſophers, and the divine Moſes, aſſerted, that the blood is alive; that is, that it poſſeſſes ſome degree of organization, or other properties different from thoſe of inanimate matter, which are not producible by any chemical proceſs, and which ceaſe to exiſt along with the life of the animal. Hence for the purpoſe of nutrition there is reaſon to ſuſpect, that two circumſtances are neceſſary, both dependent upon life, and conſequent activity; theſe are firſt an appetency of the fibrils of the fixed organization, which wants nutrition; and ſecondly, a propenſity of the fluid molecules exiſting in the blood, or ſecreted from it, to unite with the organ now ſtimulated into action. So that nutrition may be ſaid to be affected by the embrace or coheſion of the fibrils, which poſſeſs nutritive appetencies, with the molecules, which poſſeſs nutritive propenſities.

8. If the philoſopher, who thinks on this ſubject, ſhould not be inclined to believe that the whole of the blood is alive; he can not eaſily deny life to that part of it which is ſecreted by the organs of generation, and conveys vitality to the new embryon, which it produces. Hence though in the proceſs of nutrition the activity of two kinds of fibrils or molecules may be ſuſpected, yet in the proceſs of the generation of a new vegetable or animal, there ſeems great reaſon to believe, that both the combining and combined particles are endued with vitality; that is, with ſome degree of organization or other properties not exiſting in inanimate matter, which we beg leave to denominate fibrils with formative appetencies, and molecules with formative propenſities, as the former may ſeem to poſſeſs a greater degree of organization than the latter.

And thus it appears, that though nutrition may be conceived to be produced by the animated fibrils of an organized part being ſtimulated into action by inanimate molecules, which they then embrace, and may thus be popularly compared to the ſimple attractions of chemiſtry; yet that in the production of a new embryon, whether

ther vegetable or animal, both the fibrils with formative appetencies, and the molecules with formative propenſities, recriprocally ſtimulate and embrace each other, and inſtantly coaleſce, and may thus popularly be compared to the double affinities of chemiſtry. But there are animal facts, which reſemble both theſe, and are thence more philoſophically analogous to them; and theſe are the two great ſupports of animated nature, the paſſions of hunger and of love. In the former the appetency reſides only in the ſtomach, or perhaps in the cardia ventriculi, but the object conſiſts of inanimate matter; in the latter reciprocal appetencies and propenſities exiſt in the male and female, which mutually excite them to embrace each other. Two other animal facts are equally analogous; the thirſt, which reſides at the upper end of the eſophagus, and though it poſſeſſes appetency itſelf, its object is inanimate matter; but in lacteſcent females, when they give ſuck to their young, there exiſts a reciprocal appetency in the mother to part with her milk, and in the young offspring to receive it.

This then finally I conceive to be the manner of the production of the lateral progeny of vegetables. The long caudex of an exiſting bud of a tree, which conſtitutes a ſingle filament of the preſent bark, is furniſhed with glands numerous as the perſpirative or mucous glands of animal bodies; and that theſe are of two kinds, the one ſecreting from the vegetable blood the fibrils with formative appetencies, correſpondent to the maſculine ſecretion of animals; and the other ſecreting from the vegetable blood the molecules with formative propenſities, correſpondent to the feminine ſecretion of animals; and then that both theſe kinds of formative particles are depoſited beneath the cuticle of the bark along the whole courſe of it, and nearly at the ſame time by the ſympathy of the ſecreting organs, and inſtantly embrace and coaleſce, forming a new caudex along the ſide of its parent with vegetable life, and with the additional powers of nutrition, and of growth.

9. This then is the great fecret of nature; more living particles are produced by the powers of vitality in the fabrication of the vegetable blood, than are neceffary for nutrition or reftoration of decompofing organs. Thefe are fecreted, and detruded externally, and produce by their combination a new vital organization beneath the cuticles of trees over the old one. Thefe new combinations of vital fibrils and molecules acquire new appetencies, or fabricate molecules with new propenfities, and thus poffefs the power of forming the leaf or lungs at one extremity of the new caudex; and the radicles, or abforbent veffels at the other end; and fome of them, as in the central buds which terminate the branches, finally form the fexual organs of reproduction, which conftitute the flower.

That new organizations of the growing fyftem acquire new appetencies appears from the production of the paffion for generation, as foon as the adapted organs are complete; and from the defire of lactefcent females to fuckle their offspring, and alfo from the variation of the palate, or defire for particular kinds of food, as we advance in life, as from milk to flefh. Thus as a popular allufion, and not as a philofophical analogy, we may again be allowed to apply to the combinations of chemiftry; where two different kinds of particles unite, as acids and alkalies, a third fomething is produced, which poffeffes attractions diffimilar to thofe of either of them; and that new organizations form new molecules appears from the fecretions of the feminal and uterine glands, when they have acquired their maturity; and from the breafts of lactefcent females.

10. In the lateral propagation of vegetable buds as the fuperfluous fibrils or molecules, which were fabricated in the blood, or detached from living organs, and poffefs nutritive or formative appetencies and propenfities, and which were more abundant than were required for the nutrition of the parent vegetable bud, when it had obtained its full growth, were fecreted by innumerable glands on the various parts of its furface beneath the general cuticle of the tree, and there embracing

bracing and coalefcing, form a new embryon caudex, which gradually produces a new plumula and radicles. And as the different parts of the new caudex of a compound tree refemble the parts of the parent caudex, to which it adheres, it was fhewn, beyond all doubt, that different fibrils or molecules were detached from different parts of the parent caudex to form the filial one.

So in the fexual propagation of vegetables the fuperfluous living fibrils, or molecules, floating in the blood, appear to be fecreted from it by two kinds of glands only; thofe which conftitute the anthers, and thofe which conftitute the pericarp of flowers. By the former I fuppofe the fibrils, with formative appetencies and with nutritive appetencies, to be fecreted; and by the latter the molecules, with formative and with nutritive propenfities. Afterwards that thefe fibrils with formative and nutritive appetencies, become mixed in the pericarp or uterus of the flower, with the correfpondent molecules with formative and nutritive propenfities; and that a new embryon is inftantly produced by their reciprocal embrace and coalefcence. And that parts of this new organization afterwards acquire new appetencies, and form molecules with new propenfities, and thus gradually produce other parts of the growing feed, which do not at firft appear, as the plumula, radicles, cuticle, and the glands of reproduction in the pericarp and anthers, which correfpond in the animal fetus to the lungs, inteftines, cuticle, and the organs, which diftinguifh the fexes.

11. From this new doctrine of a threefold vegetable mule by lateral propagation, as the new bud on the fummit of a tree, which has had two fcions ingrafted on it one above another, in which it is inconteftibly fhewn, that different fibrils, or molecules, are detached from different parts of the parent caudex to form the filial one, which adheres to it; and that it then acquires the power of producing new radicles, or a new plumula; we may fafely conclude, as it is deducible from the ftrongeft analogy, that in the production of fexual

S mules,

mules, whether vegetable or animal, ſome parts of the new embryon were produced by, or detached from, ſimilar parts of the parent, which they reſemble. And that as theſe fibrils, or molecules, floated in the circulating blood of their parents, they were collected ſeparately by appropriated glands of the male or female; and that finally, on their mixture in the matrix the new embryon was immediately generated, reſembling in ſome parts the form of the father, and in other parts the form of the mother, according to the quantity or activity of the fibrils or molecules at the time of their conjunction.

And laſtly, that various parts of the new organizations afterwards acquired new appetencies, and formed molecules with new propenſities, and thus gradually produced other parts of the growing fetus, as the ſkin, nails, hair, and the organs which diſtinguiſh the ſexes.

If the molecules ſecreted by the female organ into the pericarp of flowers, or into the ovary of animals, were ſuppoſed to conſiſt of only unorganized or inanimate particles; and the fibrils ſecreted by the male organ only to poſſeſs formative appetencies to ſelect and combine with them; the new embryon muſt probably have always reſembled the father, and no mules could have had exiſtence.

But by the theory above delivered it appears, that the new offſpring, both in vegetable and animal reproduction, whether it be a mule or not, muſt ſometimes more reſemble the male parent, and ſometimes the female one, and ſometimes appear to be a combination of them both, as the epigram of Martial:

> Dum dubitat natura gravis puerum faceretne puellam,
> Factus es, O pulcher, pene puella, puer.

12. The certain proof above given, that ſome parts of the triple caudex of the new bud of a tree, which has been compounded by ingraftment, are formed from ſimilar parts of the triple caudex of the parent bud, carries us one ſtep further back into the myſterious proceſs

ceſs of reproduction, and ſomewhat countenances the ingenious conjectures of monſieur Buffon. And the analogy here obſerved, that as in chemical union there muſt be ſome particles of inanimate matter with attractions, and others with aptitudes to be attracted; ſo in the conjunctions of animated particles in the nutrition or formation of organized beings, there muſt exiſt fibrils or molecules with formative or nutritive appetencies, and others with formative or nutritive aptitudes or propenſities, one of which may be ſecreted by the male, and the other by the female parent, may facilitate our reaſoning upon this dark ſubject, which will be reſumed and enlarged upon in the next edition of Zoonomia, in the ſection on generation.

SECT. VIII.

I. THE MUSCLES, NERVES, AND BRAIN OF VEGETABLES.

1. Vegetable mufcles evinced by their clofing their corols, and calyxes, and moving their leaves in confequence of ftimulus. Hence alfo vegetable nerves both of fenfe and motion. When one part of a leaf of mimofa is touched the whole leaf falls. Hence alfo a vegetable brain or common fenforium. 2. Their irritability fhewn by the abforption, and circulation of their fluids By electric fhocks. By the afcent of fap-juice. 3. Their fenfibility fhewn by the collaps of mimofa. By clofing their petals from defect of ftimulus, as in darknefs and cold. By the males and females bending to each other. 4. Their volition fhewn from hedyfarum gyrans. From polymorpha marchantia. From tendrils of vines. From their fleep. 5. Their affociations of motion fhewn by their clofing their petals, performing abforption and circulation of fluids. Their acquired habits. Grains and roots from the fouth vegetate fooner. Apple-trees. Senfitive plant. Berberry. 6. Vegetables poffefs a fenfe of heat, of light, and of moifture, and confequently poffefs a brain or common fenforium. 7. They poffefs a fenfe of touch and a common fenforium. 8. How do the anthers and ftigmas find each other? by a fenfe of fmell. Adultery of collinfonia. 9. From their abforptions, fecretions, fenfes, love and fleep, they muft poffefs a brain. Does this refide in the pith of each individual bud?

1. THE various motions of peculiar parts of vegetables evince the exiftence of mufcles and nerves in thofe parts, fuch as the clofing of their petals, and calyxes, at the approach of night, or in cold or wet weather; though the fibres and nerves, which conftitute thefe mufcles, are too fine for anatomical demonftration.

Some vegetables fold the older leaves over the new buds at the extremity of their ftalks during the night, as alfine, chickweed; others, as the mimofa, fenfitive plant, fold the upper or polifhed fides of their

their leaves together during their ſleep. The hedyſarum gyrans whirls its leaves in various directions, when the air is ſtill, by an apparently voluntary effort, probably for the purpoſe of reſpiration. The dionœa muſcipula, Venus's fly-trap, cloſes its leaves from the ſtimulus of inſects, which crawl upon them, and pierces them with its prickles. And the apocynum androſemifolium contracts its petals or nectaries round the proboſcis of the flies, which ſtimulate it, and holds them till they die, or till the ſleep of the plant releaſes them by the relaxation of its muſcular action.

From theſe circumſtances it appears, that there are not only muſcles about the moving foot-ſtalks or claws of the leaves and petals above mentioned; but that theſe muſcles muſt be endued with nerves of ſenſe as well as of motion. Now, as when one part of a leaf of mimoſa is touched, the whole leaf falls, it follows, that there muſt be a common ſenſorium, or brain, where the nerves communicate, belonging to this one leaf-bud. To evince this further another leaflet was ſlit with ſharp ſciſſars, and ſome ſeconds of time elapſed, before the plant ſeemed ſenſible of the injury; and then the whole plant collapſed as far as the principal ſtem. Afterwards a ſmall drop of oil of vitriol was put on the bud in the boſom of a leaf of another ſenſitive plant; and, after about half a minute, when the brain of this bud could be ſuppoſed to be deſtroyed, the whole leaf fell, and roſe no more. If the individual buds of plants poſſeſs muſcles and nerves with a brain, or common ſenſorium; the following queſtions conſequently occur, and ſhould be anſwered in the affirmative. Have vegetable buds irritability? have they ſenſation? have they volition? have they aſſociations of motion? I am perſuaded they poſſeſs them all, though in a much inferior degree even than the cold blooded animals.

2. The irritability of vegetable fibres is demonſtrated by the abſorption and circulation of their fluids in their roots, leaves, and petals; which can not be explained by any mechanic law, and exactly correſponds

correfponds with the abforption of the aliment, and the circulation of the blood in animals; which Phyfiologifts have demonftrated to depend on the mufcular motions of the veffels themfelves, which poffefs irritability, and are excited into action by the ftimulus of the fluids, which they acquire or contain.

The irritability of vegetable veffels is fhewn by a curious experiment of Von Uflar, who paffed ftrong electric fhocks through a plant of euphorbia, fo as to deftroy the life of the plant; and he then obferved on cutting off a branch, that it did not bleed; though a fimilar branch cut off before the death of the plant effufed much milky juice; whence he juftly concludes, that the electric percuffion had deftroyed the irritability of the plant.

Mr. Cavallo afferts in his Treatife on Electricity, that he found by repeated experiments, that the plant balfam (impatiens) was deftroyed by lefs quantities of electricity than any other vegetables, which he fubjected to it; and that on examining the plant afterwards no injury on the external or internal parts of it could be difcovered; whence it may be concluded that the irritability fimply, and not the organization of the plant, was deftroyed by the unnatural quantity of ftimulus. He adds, that not only fhocks from fo fmall a coated furface as fix or eight fquare inches, but even ftrong fparks from a large conductor deftroyed thefe plants, which fometimes recovered in a day or two, but not frequently. See Sect. XIII. 3. and Sect. XIV. 2. 3. of this work.

The afcent of the fap-juice during the vernal months in the experiments both of Hales and Walker, being retarded or quite ftopped during the cold parts of the day, and in the night; and on the north fide of the tree in cool days, when it continued to flow on the fouth fide, can only be afcribed to the irritability of the vegetable veffels being decreafed by the deficient ftimulus of heat. See this fubject further treated of in Sect. XIV. 1. 10. of this work.

3. The fenfibility of fibres is diftinguifhed from their irritability

by the pain or pleafure, which precedes or attends any animal action; and therefore fuppofes the exiftence of a common fenforium; now when one divifion of a leaf of mimofa is injured by a wound or touch, in a fhort time the whole leaf clofes, which is owing to the actions of the diftant mufcles about the footftalks of the fubdivifions of the leaf. Does not this prove, that there is a brain or common fenforium, where the nerves communicate in fome part of this bud or leaf, as the injury of one diftant part of it thus affects the whole? or in other words, that the difagreeable fenfation is propagated from a part to the whole, and caufes the actions of fome diftant mufcles, in the fame manner as I draw away my hand when my finger is hurt?

There are mufcles placed about the foot-ftalks of the leaves or leaflets of many plants, for the purpofe of clofing their upper furfaces together, or of bending them down fo as to fhoot off the fhowers or dew-drops, as in fenfitive plant, mimofa; kidney-bean, phafeolus; and many trees. The claws of the petals, or of the divifions of the calyx of many flowers, are furnifhed in a fimilar manner with mufcles, which are exerted to open or clofe the corol and calyx of the flower, as in tragopogon, anemone. This action of opening and clofing the leaves or flowers does not appear to be produced fimply by irritation on the mufcles themfelves, but by the connexion of thofe mufcles with a fenfitive fenforium, or brain, exifting in each individual bud or flower. 1ft. Becaufe many flowers clofe from defect of ftimulus, not by the excefs of it, as by darknefs, which is the abfence of the ftimulus of light; or by cold, which is the abfence of the ftimulus of heat. Now the defect of heat, like the abfence of food, or of drink, affects our fenfes with pain, which had been previoufly accuftomed to a greater quantity of them, and a cutaneous fhivering may be excited in confequence of the pain; but a mufcle cannot be faid to be ftimulated into action by a defect of ftimulus, though fome modern writers on medicine have called cold a ftimulus to animal fibres, which it always renders torpid or inactive; a theory

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derived from Galen, and which muſt have originated in his total ignorance of chemiſtry and natural philoſophy.

In ſome flowers the males bend into contact with the females, as in ciſtus, kalmia, fritillaria perſica, lithrum ſalicaria; in others the female bends to the males, as in collinſonia, glorioſa, geniſta, epilobium; which ſhews a ſenſibility to the paſſion of reproduction. In *irritation* the ſtimulated muſcles only are brought into action, without being perceived by the other parts of the ſyſtem; but in *ſenſation* the whole ſyſtem is affected by means of the brain or common ſenſorium, and thence very diſtant muſcles are brought into action to acquire an agreeable object, or to repel or withdraw from a diſagreeable one. See Zoonomia, Vol. I. Sect. XIII. 2.

4. That plants poſſeſs in ſome degree the power of volition would appear firſt from the hedyſarum gyrans, which moves its leaves in circular directions when the air is too ſtill. Secondly, from the marchantia polymorpha, in which ſome yellow wool advances from the flower-bearing anthers, while it drops its duſt like atoms. Murray's Syſtem of Vegetables. Thirdly, from the tendrils of vines, and the ſtems of other climbing vegetables, which continue to move round, till they find ſomething to adhere to, or till they have rolled themſelves up in a ſpiral line like a cork-ſcrew. And laſtly, from the efforts of almoſt all plants to turn the upper ſurface of their leaves, or their flowers, to the light.

But there is an indubitable proof of plants poſſeſſing ſome degree of voluntarity, and that is deduced from their ſleep. In animal bodies ſleep conſiſts in a ſuſpenſion or temporary abolition of voluntary power; the organs of ſenſe being at the ſame time cloſed, or by ſome other means rendered unfit for the perception of external bodies. Now the ſleep of plants is proved by the hanging down or cloſing of the leaves of many plants, and of ſhutting the petals and calyxes of many flowers in the dark, and their again opening or expanding them in the light, or at certain hours of the day.

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5. In refpect to vegetables acquiring affociations of motion, or habits of action, the former is feen in the abforptions and circulations of their fluids, and in the various movements above defcribed; which whirl their leaves or tendrils, and clofe or open their corols and calyxes, which could not be performed without the fynchronous and affociated actions of many mufcles; as in the abforptions and circulations of animal bodies, and the movements of their limbs.

Other acquired habits of vegetable actions appear from the grains and roots brought from more fouthern latitudes, which germinate here fooner than thofe which are brought from more northern ones, owing to their acquired habits. Fordyce on Agriculture. And from the apple trees fent from hence to New York, which bloffomed for a few years too early for the climate, and bore no fruit; but afterwards learnt to accommodate themfelves to their new fituation. Travels in New York by Profeffor Kalm.

The divifions of the leaves of the fenfitive plant have been accuftomed to contract at the fame time from the abfence of light; hence if by any other circumftance, as a flight ftroke or injury, one divifion is irritated into contraction; the neighbouring ones contract alfo, from their motions being affociated with thofe of the irritated part. So the various ftamina of the barberry have been accuftomed to contract together in the evening; and thence, if you ftimulate one of them with a pin, according to the experiment of Dr. Smith, they all contract from their acquired affociations.

6. This leads us to a curious inquiry, whether vegetables poffefs any organs of fenfe? Certain it is, that they poffefs a fenfe of heat and cold, another of moifture and drynefs, and another of light and darknefs; for they clofe their petals occafionally from the prefence of cold, moifture, or darknefs. And it has been already fhewn, that thefe actions cannot be performed fimply from irritation, becaufe cold and darknefs are defective quantities of our ufual ftimuli; and that on that account fenfation or volition are employed; and in confe-

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quence a ſenſorium or union of the nerves muſt exiſt. So when we go into the light, we contract the iris, not from any ſtimulus of the light on the fine muſcles of the iris, but from its motions being aſſociated with the ſenſation of too much light on the retina, which could not take place without a ſenſorium or center of union of the nerves of the iris with thoſe of viſion.

7. Beſides theſe organs of ſenſe, which diſtinguiſh cold, moiſture, and darkneſs, the leaves of mimoſa, and of dionæa, and of droſera, and the ſtamens of many flowers, as of the barberry, and of the numerous claſs of ſyngeneſia, are ſenſible to mechanic impact; that is, they poſſeſs a ſenſe of touch; and as many of their diſtant muſcles are in conſequence excited into action, this alſo evinces, that they poſſeſs a common ſenſorium, by which this ſenſation is communicated to the whole, and volition occaſionally exerted.

8. Laſtly, in many flowers the anthers when mature approach the ſtigma, in others the female organ approaches to the male. I aſk, by what means are the anthers in many flowers, and ſtigmas in other flowers, directed to find their paramours? Is this curious kind of ſtorge produced by mechanic attraction, or by the ſenſation of love? The latter opinion is ſupported by the ſtrongeſt analogy, becauſe a reproduction of the ſpecies is the conſequence; and then another organ of ſenſe muſt be wanted to direct theſe vegetable amourettes to find each other; one probably analagous to our ſenſe of ſmell, which in the animal world directs the new-born infant to its ſource of nouriſhment; and in ſome animals directs the male to the female; and they may thus poſſeſs a faculty of perceiving as well as of producing odours.

A moſt curious example of the exiſtence of ſome kind of ſenſe, which may direct the piſtils, or female parts of the flowers of collinſonia, which way to bend for the purpoſe of finding the mature males, is related in Botanic Garden, Vol. I. Canto IV. l. 460, where ſome of the piſtils miſtake the males, or ſtamens, of the neighbouring flowers

flowers for their own hufbands; and bending into contact with them become guilty of adultery. See Sect. VII. 2. 2. of this work.

9. Thus, befides a kind of tafte or appetency at the extremities of their roots, fimilar to that of the extremities of our lacteal veffels, for the purpofe of felecting their proper food; and befides different kinds of irritability or appetency refiding in the various glands, which feparate honey, wax, refin, and other juices from their blood; vegetable life feems to poffefs an organ of fenfe to diftinguifh the variations of heat, another to diftinguifh the varying degrees of moifture, another of light, another of touch, and probably another analogous to our fenfe of fmell. To thefe muft be added the indubitable evidence of their paffion of love, and of their neceffity to fleep; and I think we may truly conclude, that they are furnifhed with a brain or common fenforium belonging to each bud.

But whether this brain, or common fenforium, refides in the medulla, or pith, which occupies the central parts of every bud and leaf, like the fpinal marrow of animals, has not yet been certainly determined. By this medulla is meant only the pith of each individual bud, not that which is feen in the center of a tree, which, like the wood which furrounds it, has long ceafed to have vegetable life.

The pith, or medulla of each bud, is fuppofed by its elafticity to pufh out the central part of the bud; as the veficular productions on the infide of young quills are fuppofed to pufh forwards their early growth, and in fome birds are faid by Mr. Hunter to receive air from the lungs. It is more probable that this pith, or medulla oblongata of plants, fupplies the fpirit of vegetation, fince it exifts in all buds in their moft early ftate, and does not communicate from one bud to another, and thus diftinguifh them from each other, and evinces their individuality. See Sect. I. 8. and IX. 2. 4.

PHYTOLOGIA.

PART THE SECOND.

ECONOMY OF VEGETATION.

SECT. IX.

THE GROWTH OF SEEDS, BUDS, AND BULBS.

I. 1. Seeds *resemble eggs.* 2. *The embryon is of different maturity. The leaves visible in some seeds.* 3. *Why the plumula ascends and the root descends. Is nourished by the seed-lobes, by the fruit. Becomes a dwarf if deprived of them. Melons and cucumbers are too luxuriant. Turnep-seed should be new.* 4. *Seeds have hard shells, have acrid rinds with bitter or narcotic juices, but pure starch may be procured from them.* 5. *Umbilical vessels, and roots of seeds. Annual, biennial, and perennial plants. Reservoirs of nutriment in their roots. All plants are biennials. Bulbs and buds succeed each other many times before they flower.* 6. *Wheat. Stems and roots round the first joint. Has no nectary. Is greatly increased by transplanting.* II. 1. Buds *are a viviparous progeny. Protected by scales and varnish. Grow by piping with more heat and moisture as they exhale less. Are individual, annual, or biennial plants.* 2. *Buds of herbs. Evergreens have no bleeding season.* 3. *Buds of deciduous trees are in different states of maturity, as in hepatica, daphne, osmunda. Some buds are invisible.* 4. *Importance of the pith like the spinal marrow; it lines hollow stalks.* 5. *Reservoir of nutriment for buds. Their umbilical vessels.* 6. *A bud contains many embryons. The first leaf-buds often destroyed by insects. The flower-buds only injured by them.* 7. *Vigorous branches produce leaf-buds, weak ones flower-buds. Why seedling apples are long before they bear. Why pears bear only at their extremities.* 8. *New buds may be made either leaf-buds by lopping a part of the branch, or flower-buds by bending the branch down, or cutting a ring in the bark, or strangulating* *it with a wire. Debarked oaks pullulate. Sap-juice in the alburnum.* 9. *A pauſe in vegetation about midſummer. Trees then ſecrete nutriment in their roots and ſap-wood for the new buds. Are then beſt tranſplanted without lopping their branches.* 10. *Caudexes of the buds form the bark, whoſe veſſels inoſculate. Heart-wood dies. Sap-wood acts as umbilical veſſels, and afterwards as capillary tubes, or as capillary ſyphons.* 11. *Flower-buds periſh without increaſing the bark by new caudexes. Are convertible into leaf-buds. Vegetable monſters.* 12. *Central part of an adult bud.* III. I. BULBS. *Leaf-bulbs precede flower-bulbs in the tulip as leaf-buds in apple-trees, as joints in the ſtalk of wheat. Solitary generation of inſects.* 2. *Bulbs of onions. Orchis. Tulip. Hyacinth. Ranunculus. Iris.* 3. *Roots of potatoes. Wires of ſtrawberries. Seeds of orchis. Flowers of potatoes.* 4. *Stem-bulbs on magical onions are ſimilar to root-bulbs.* 5. *Root-grafting. Root-inoculation. Root-propagation. Suckers of trees. Root-buds of herbaceous plants. Internal parts of which decay.* 6. *Tuberous roots of turnep and carrot are reſervoirs of nutriment for the ſucceeding flower-ſtem. No flower-bud is ever produced from a ſeed without previous leaf-buds. Why ſeedling apple-trees are ten or twelve years before they bear fruit. Magazines of aliment in almoſt all roots.* 7. *Uſe of the horſe-hoe to accumulate earth round the wheat-plants. Wheat dropped on the ſoil ſhoots up but one ſtem. Covered with the ſoil it ſhoots up many. And tranſplanted deeper in the ſoil many more. Potatoes, vines, and figs, produce lateral roots from their joints. So does the bark if wounded circularly. Uſe of eating down forward wheat with ſheep.*

I. I. HAVING treated of the phyſiology, we now ſtep forwards to conſider the economy of vegetation, as far as it may ſerve the purpoſes of agriculture and gardening.

After the production of the ſeed, or vegetable egg in the pericarp of flowers, and its enſuing impregnation by the farina of the anthers ſhed upon the ſtigma, a coagulated point appears on the ſeed-lobes according to the obſervations of Spallanzani, like the cicatricula on the yolk of the egg.

The ſeed continues to grow in the pericarp ſuſtained by adapted ſecretions from the vegetable blood, which is previouſly oxygenated in the bractes or floral-leaves of many plants; in others the feed is itfelf inclofed in an air-veffel probably for that purpofe, as in ftaphylea, bladder nut, and tagetes, African marygold. At the fame time a refervoir of nutriment is fecreted, and depofited in the feed-lobes or cotyledons, which are fingle ones in the feeds of palms, graffes, and lilies; though twofold in thofe of moft other herbs and trees; whence the ftricteft analogy exifts between feeds and eggs.

2. In fome feeds, when they leave the vegetable uterus, this embryon is much more mature than in others. In the feeds of the nymphæa nelumbo the leaves of the future plant were feen fo diftinctly by Mr. Ferber, that he found out by them to what plant the feeds belonged. The fame in the feeds of the tulip-tree, liriodendron tulipiferum. Amæn. Acad. V. VI. No. 120. And Mr. Baker afferts, that on diffecting a feed of trembling grafs, he difcovered by the microfcope a perfect plant with roots fending forth two branches, from each of which feveral leaves or blades of grafs proceeded. Microfc. Vol. I. p. 252. While in other feeds the corculum, or heart only of the feed, is diftinctly vifible, as in the kernel of the walnut, and the feed of the garden-bean. So in the animal kingdom the young of fome birds are much more mature at their birth than thofe of others. The chickens of pheafants, quails, and partridges, can ufe their eyes, run after their mothers, and peck their food, almoft as foon as they leave their fhell; but thofe of the linnet, thrufh, and blackbird, continue many days totally blind, and can only open their callow mouths for the offered morfel.

3. When the feed falls naturally upon the earth, or is buried artificially in fhallow trenches beneath the foil, the firft three things neceffary to its growth are heat, water, and air. Heat is the general caufe of fluidity, without which no motion can exift; water is the menftruum, in which the nutriment of vegetable and animal bodies is conveyed to their various organs; and the oxygen of the atmofphere is believed to afford the principle of excitability fo perpetually neceffary

neceſſary to all organic life; and which renders the living fibres both of the vegetable and animal world obedient to the ſtimuli, which are naturally applied to them.

Whence we may in ſome meaſure comprehend a difficult queſtion; why the plume of a ſeed ſowed upon, or in the earth, ſhould aſcend, and the root deſcend, which has been aſcribed to a myſterious inſtinct; the plumula is ſtimulated by the air into action, and elongates itſelf, where it is thus moſt excited; and the radicle is ſtimulated by moiſture, and elongates itſelf thus, where it is moſt excited, whence one of them grows upwards in queſt of its adapted object, and the other downward.

The firſt ſource of nutriment ſupplied to the ſeminal embryon, after it falls from the parent plant, exiſts in the ſeed-lobes, or cotyledons, which either remain beneath the earth, and are permeated by the umbilical veſſels of the embryon plant, which abſorb the mucilaginous, farinaceous, or oily matter depoſited in them, as in the bean, piſum; or the ſeed-lobes riſe up into the air along with the young plant, as in the kidney-bean, phaſeolus, become ſeed-leaves, and ſerve both as a nutritive and reſpiratory organ. Theſe cotyledons or ſeed-lobes generally contain mucilage, as in quince-ſeed; or ſtarch, as in wheat; or oil, as in line-ſeed. Some of theſe nutritive materials are probably abſorbed unchanged, or diſſolved only by the moiſture of the earth; others are converted into ſugar partly by a chemical proceſs, and partly by the digeſtive powers of the young plant, as appears in the proceſs of germinating barley, and converting it into malt; theſe reſervoirs of nutriment are hence perfectly analogous to the white of the egg, a part of which is probably abſorbed unchanged by the lymphatics of the young embryon, and a part of it converted into a ſweet chyle for the nouriſhment of the chick, when it has acquired a ſtomach.

If the ſeed be deprived of theſe cotyledons, ſoon after the root appears, it will continue to grow, but with leſs vigour, and is ſaid to produce

duce a dwarf plant from three to nine times lefs than the parent. Hence the feeds of plants, which are liable to produce too vigorous roots, and thence have not time to ripen their fruits in the fhort fummers of this climate, or which fill our hot-beds with too luxuriant foliage, as melons, and cucumbers, fhould in this climate be kept three or four years; by which part of the mucilaginous, or farinaceous, or oily matter of the cotyledons becomes injured or decayed, and the new plant grows lefs luxuriantly.

Another fource of nutriment for the feminal embryon of many plants exifts in the fruit, which envelopes the ftone or feed-veffel, after the growing fetus has burft its confinement, and fo far refembles the yolk of the egg, which becomes a nutriment to the chick, after it has confumed the white, and eloped from its fhell.

When mature fruit, as an apple or a cucumber, falls upon the ground, it fupplies, as it ripens or decays, a fecond fource of nourifhment, which enables the inclofed feeds to fhoot their roots into the earth, and to elevate their ftems with greater vigour. Hence fruits generally contain a faccharine matter, or juices capable of being converted into fugar, either by a fpontaneous chemical procefs, as in baking four apples; or by a vegetable procefs, as in thofe four pears, which continue to ripen for many months both before and after they are plucked from the tree, as long as life remains in them; that is, till they ferment or putrify; and laftly, by the digeftive power of the young embryon, as above mentioned.

If the feed be deprived of the fruit, it will indeed vegetate, but with lefs vigour. Hence thofe feeds which are liable to produce too vigorous fhoots for this climate, as the feeds of melons and cucumbers, fhould be wafhed clean from their pulp, before they are hoarded, and preferved three or four years before they are fown in hot beds. But thofe feeds, which are fown late in the feafon for the purpofe of producing winter fodder, as the feeds of turneps, fhould be collected and preferved with every poffible advantage; and on this account new ſeed is much to be preferred to that which has been long kept.

4. Many ſeeds when mature are diſperſed far from the parent tree, for the purpoſe of their growth, by various contrivances, as mentioned in Sect. VII. 2. 5. Some of theſe are ſurrounded with hard ſhells, which are impenetrable by inſects, as they lie on the earth to take root, as peaches, nectarines, nuts, cocoa-nuts. Other ſeeds are furniſhed with an acrid covering to prevent the depredation of inſects, as the peel of oranges and lemons, the outward huſk and inward rind of walnuts, and of caſhew-nuts, and the ſkin of muſtard-ſeed, and rape-ſeed; other ſeeds for the ſame purpoſe abound with bitter or narcotic juices, as the horſe-cheſnut, acorn, apricot, cherry, many of which ſupply materials to the ſhops of medicine, and may ſupply nutriment in times of ſcarcity; as the ſtarch, which they contain, may be procured by grating them into cold water, and waſhing away the mucilage, and the poiſonous material, which adheres to it, or which is ſoluble in water.

5. The plumula of the ſeed, or embryon plant, abſorbs the nutriment laid up for it in the ſeed-lobes by veſſels, which permeate them for that purpoſe, and have been termed umbilical veſſels; and afterwards ſhoots its roots down into the fruit, or into the earth, in ſearch of other nouriſhment; and expands its leaves in the air as an organ of reſpiration.

Thoſe plants, which are uſually termed annuals, produce their flowers and die in the ſame year in which their ſeeds are ſown; as barley, oats, and a variety of garden flowers. Theſe nevertheleſs in accurate language ſhould be termed biennials, becauſe the ſeed in this climate is produced in one ſummer; and the embryon plant becomes mature in the next; as the ſeed is generally preſerved in our granaries, or ſeed-boxes, and not committed to the ground till the enſuing ſpring; for many of theſe vegetables are not natives of this

climate,

climate, and would periſh if the ſeeds were ſown in autumn, when it is naturally ſcattered on the earth.

Thoſe which are uſually termed biennial plants, differ from the former, firſt in the time of ſowing the ſeed, which is generally in the early autumn, as ſoon as it is ripe, as of turneps, carrots, wheat; and thus theſe produce their flowers in the ſecond year after the ſeed is ſown, which has given them the name of biennials. Many of theſe plants, perhaps all of them, lay up a reſervoir of nutritious matter during the ſummer or autumn in their roots. This nutriment is ſecreted from the vegetable blood, which is previouſly oxygenated for that purpoſe in the large leaves, which generally ſurround the caudex of the plant, as in turneps and carrots. Theſe leaves ſurvive the winter in many plants, which the more ſucculent ſtems probably would not; and the nutriment depoſited in the root is expended in the growth of the ſtem and the production of ſeed in the enſuing ſpring. As in theſe vegetables one of our ſummers is too ſhort for their growth from the ſeed to the fructification; and it is for this reſervoir of nutriment that theſe plants are generally cultivated.

But thoſe plants, which are termed perennial, when firſt raiſed from ſeed, are many of them ſome years before they produce flowers. Some of them form bulbous roots, as the tulip, hyacinth, onion, which are three or four years before they flower, during which time I believe all the bulbs die annually, producing one larger than that of the preceding year, and perhaps ſome ſmaller ones, all which annually increaſe in ſize till they flower. The ſame occurs in potatoe-roots raiſed from ſeed, which do not flower as I am informed till the third year, and then only thoſe which ſeemed of ſtronger or forwarder growth.

Other perennial plants have palmated or branching roots; in ſome of theſe, as in ſeedling apple-trees, the flower is ſaid not to appear till ten or twelve years after the ſeed is ſown; the buds nevertheleſs annually dying and producing other buds over them, perhaps more perfect ones, as they acquire after a few years the power of producing sexual organs, and in consequence a seminal progeny. In these perennial herbaceous plants and trees a magazine of nutriment is provided in their roots or sap-wood, to supply the new buds, which are to grow in the ensuing spring.

Whence it appears, that all the vegetables of this climate may be termed biennial plants; as the seeds of some, and the buds or bulbs of others, are produced in one summer, and flourish and die in the next; those which are called annuals or biennials leaving behind them a future progeny of seeds only; those, which are termed perennial herbaceous plants, leaving behind them the first year or two a progeny of bulbs or root-buds only, and afterwards a progeny of seeds also; while the perennial arborescent vegetables leave behind them a progeny of buds only for several successive years, and afterwards a progeny of both buds and seeds.

Thus the bulb from a tulip-seed produces a more perfect bulb annually, till it flowers, I believe, on the fifth year. It then produces a flower, and also one perfect bulb, which flowers the next year; and some other less perfect bulbs, which are succeeded by more perfect ones annually, till they also flower. Whence I conclude, that no tulip bulb flowers till the fourth or fifth generation.

It is probable, that a similar circumstance occurs in other vegetables, as in apple-trees; and that the buds of these do not produce sexual organs, and a consequent seminal progeny, till the twelfth or fourteenth generation of the bud from the seed; each of those buds nevertheless producing one principal bud annually more perfect than itself, and many lateral buds less perfect than itself; that is, at a greater distance from that state of maturity which enables it to form a flower. This art of distinguishing the greater or less maturity of buds is a matter of great importance in the management of fruit-trees, as in many of them the central bud becomes a spur one year, and flowers the

the next; and the lateral buds one or two years afterwards, as will be mentioned in Sect. XV. on the production of fruit.

6. In wheat there exists about the caudex a reservoir of nutritious juices deposited in the autumn for the purpose of raising the stem in the ensuing spring like that of turneps and carrots; but which is attended with other circumstances peculiar I suppose to the grasses, and other plants, which possess only one cotyledon or seed-lobe. The early leaf, which surrounds the first joint of the stem, withers, as the spring advances; in which joint it had previously deposited a saccharine juice, and probably some new embryon buds were at the same time generated in the caudex; for through this withered leaf, which surrounds the first joint of the stem within the earth, a circular set of new stems issue adhering to it, and a circle of roots below them adhering to the caudex or base of it. These new buds rise into air, and shoot their roots into the earth; and in this manner many stems are produced in the spring from one seed sowed in the autumn preceding; though in some kinds of wheat the whole process of the seed rising from earth, and producing other stems round the principal one, and of ripening its seeds, may be performed in one summer even in this northern climate.

Another peculiarity attends the growth of wheat and other grasses; the leaf, which surrounds and strengthens the stem by its foot-stalk, deposits at every lower joint a saccharine matter for the purpose of nourishing the ascending part of the young stem; and in the uppermost joint, I suppose, to serve instead of honey for the stamens and stigmas, as their flowers have no visible nectary; and as the scales of the flower may with good reason be esteemed a calyx rather than a corol, according to the opinion of Mr. Milne; as these scales attend the seed-vessel to its maturity, which the corol does not. Milne's Botanical Dict. Art. Gramina.

Owing to this secretion of saccharine matter at the foot-stalk of every leaf, and its collection round the joints of grasses, it happens that

that when theſe joints are ſurrounded with moiſt earth, and are placed but a certain depth from the air, that new buds will put forth round theſe joints, and ſtrike their roots into the ſoil. Whence the agrarian huſbandman may derive great advantage from tranſplanting his wheat, after it has produced a circle of new ſtems from the firſt joint of the ſtraw; for if he then parts and replants them an inch or two deeper in the ground, ſo as to cover the firſt joint of each of theſe additional ſtems, he may multiply every one of them four or ſix times, and thus obtain twenty or thirty ſtems from one original ſeed. See No. III. 1. and 7. of this ſection.

II. 1. Other vegetable embryons are produced in the buds on the ſtems or branches of trees, which may be termed the viviparous progeny of plants, in contradiſtinction to thoſe from ſeeds, which may be termed their oviparous progeny. Theſe buds are either leaf-buds or flower-buds, or both in one covering; the bud is termed hybernaculum, or winter-cradle, of the embryon ſhoot, and is covered with ſcales, and often with a reſinous varniſh, as in tacamahacca, to protect it from the cold and moiſture of the enſuing winter, and from the depredation of inſects.

Theſe by inoculation or ingrafting on other ſtems of trees, or by being planted in the earth, become plants exactly ſimilar to their parents. A ſmall glaſs inverted over theſe buds, when ſet in the earth, contributes to inſure their growth by preventing too great an exhalation; otherwiſe they are liable to perſpire more than they can abſorb, before they have acquired roots; this the gardeners call piping a ſlip, or a cutting, of a plant. In this ſituation a greater heat may be given them, as in hothouſes, without increaſing their quantity of perſpiration, which ceaſes as ſoon as the air in the glaſs is ſaturated with moiſture; and the increaſe of heat much contributes to the protruſion of their roots and new buds, as they can at the ſame time bear to be ſupplied with a greater quantity of moiſture.

Every bud of moſt of the deciduous trees of this climate may there-

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fore be confidered as an individual biennial plant, as diftinctly fo as a feed; that is, the bud like a feed is formed in one fummer, grows to maturity in the next, and then dies. In fome trees neverthelefs of this climate, as the mock orange, philadelphus, acacia, viburnum; and in the evergreen fhrubs or trees, as holly, laurel, vinca, heath, and rue; and in all thofe herbs commonly called annuals; and in moft of the trees of warmer climates; the buds appear to be formed in the vernal months, and to arrive at their maturity during the fame year; and may therefore properly be called annual plants.

2. The bud of thefe herbs, which are commonly called annuals, rifes in the bofom of a leaf; and, as it adheres to its parent, requires no female apparatus to nourifh it, but gradually ftrikes down roots from its caudex into the ground, which caudex forms a part of the bark of the increafing plant. This occurs in thofe herbaceous vegetables, which have juft rifen from feeds; the buds of which are properly individual annual plants, which grow to maturity adhering to the parent, and do not therefore refemble a feed or egg, as there is no refervoir of nutriment laid up for them.

This circumftance alfo happens, I fuppofe, to the evergreen fhrubs and trees of this climate, as to heath, rue, box, pine, laurel; for in thefe vegetables, as the leaf does not die in the autumn, it continues to oxygenate the blood, and to fupply nourifhment to the bud in its bofom during the fine days of winter, and in the fpring, and furvives till near midfummer; that is, till the new bud has expanded a leaf of its own. Whence I fuppofe thefe evergreens lay up in fummer no ftore of nutriment in their roots or alburnum for the fuftenance of their enfuing vernal buds; and have thence probably no bleeding feafon like deciduous trees.

But the embryon in a bud of a deciduous plant leaves in the fpring of the year its winter cradle, or hybernaculum, like the embryon in a feed, or a chick in the egg; and like thefe the young plants of different vegetables have previoufly arrived at different ftates of matu-

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rity. Thus Mr. Ferber aſſerts, that he was delighted in obſerving in the buds of hepatica, and pedicularis hirſuta, yet lying in the earth, and in the gems of the ſhrub daphne mezereon, and at the baſe of oſmunda lunaria, a perfect plant of the future year diſcernible in all its parts; thus alſo in horſe-cheſnut the leaves, and in cornel-tree the flowers, are each diſtinctly viſible during the winter in their reſpective buds. Amœn. Acad. Vol. VI. No. CXX. Milne's Dict. Art. Gemma.

While in buds of many other trees, and probably in all the more backward buds, which are formed late in the ſummer on the lower parts of branches, and much deprived of light and air, the embryon is not ſo forward as to be eaſily diſcernible; and in thoſe ſhrubs or trees, which are deciduous in this climate, and yet have no apparent buds in winter, as the philadelphus, mock orange, viburnum, and many ſhrubs. I ſuſpect there is nevertheleſs an embryon ſecreted from the blood at the foot-ſtalk of each leaf, though it is not ſo forward as to protrude through the bark, and produce a prominent bud, or hybernaculum. The ſame I ſuſpect to occur in reſpect to trees, which loſe their leaves in winter, in warmer climates, in which they are ſaid not to produce autumnal buds; as I can not conceive by what means freſh leaf-buds can be generated in the ſpring, when the leaves, which conſtitute the lungs of the mature living part of the tree, are dead; and the whole of that mature living part, or laſt year's bud, conſequently dead along with them. But if the caudex of the new bud be generated without the plumula, or viſible bud, it can certainly produce a plumula for itſelf in the enſuing ſpring, as is ſeen by the production of new buds, when a branch is cut off, round the remaining trunk, as is done frequently to the ſtems of willows.

In ſimilar manner the viviparous offspring of different animals arrive at different ſtates of perfection before they are born, as calves and foals can ſtand erect in an hour, and quickly learn to uſe their eyes, and to run after their mothers; while the blind puppy, and kitten, and the downlefs rabbit, are long before they can leave the neft which the parent has provided for them.

4. The prefence of the pith or medulla is of great importance to the growth of the new bud, as may be obferved by gradually flicing a fhoot of a horfe-chefnut in autumn, or in the early fpring. The rudiments of the feven feparate ribs of the late parent-leaf, and the central pith of the bud in its bofom, are feen to arife or terminate near the pith of the parent fhoot, where the embryon plumula is probably fecreted by a gland at the bottom of the parent leaf-ftalk, finds there its firft reception and nourifhment, and is gradually protruded and elongated by the pith, which exifts in its center, as the bud proceeds, and thus conftitutes the afcending caudex or uterus of the new bud; which is refembled by the wires of ftrawberries, and other creeping vegetables; whereas the defcending caudexes of the new buds, which form the filaments of the bark of trees, are fecreted from the various parts of the old bark in their vicinity; all which probably occur at the fame time by fympathy, as fhewn in Sect. VII.

The pith thus appears to be the firft or moft effential rudiment of the new plant, like the brain or fpinal marrow, medulla oblongata, which is the firft vifible part of the figure, I believe, of every animal fetus, from the tadpole to mankind.

In thofe plants which have hollow ftems, this central cavity, though not filled with the pith or medulla, appears to be lined with it; as in picris and tragopogon; in the former the ftem is not only lined with the pith, but wherever a new bud is generated on the fummit of the afcending ftem, or in the bofom of a leaf, a membranous diaphragm divides the cavity, and is covered with this medullary fubftance, which divifion thus diftinguifhes one bud from another; and in flicing away the part of the ftem of tragopogon, where the new lateral bud adheres, the medulla or pith in the center of the bud is feen to commence near that membrane which lines the ftem, and to pafs through the circle of arterial, venal, and abforbent veffels, which conftitute

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the aſcending caudex, or uterus, of the new bud, while the deſcending caudex of it is ſecreted from the various parts of the older bark in its vicinity.

Something ſimilar to this mode of the production of the buds of trees had not eſcaped the ingenious Mr. Bradley, who aſſerts, "that buds have their firſt riſe in the pith; they are there framed, and furniſhed with every part of vegetation, and forced forwards to meet the air through the tender bark, and would drop on the ground, if they were not reſtrained by veſſels, which ſerve as roots to nouriſh them; and thus as a ſeed takes root in the earth, a bud takes root in the tree; but with this difference, that the ſeed has lobes to ſupply it with nouriſhment, till it can ſelect juices from the earth; but the bud has no occaſion for lobes, becauſe it takes root immediately in the body of the tree, where the proper juices are already prepared for it." Diſcourſes on Growth of Plants, 1727, p. 56.

5. As the ſeed was nouriſhed in the pericarp by an adapted ſecretion from the vegetable blood oxygenated in the bractes or floral-leaves; and as a reſervoir of nutriment was alſo prepared for it afterwards in the ſeed-lobes and fruit: ſo the bud is at firſt nouriſhed in the boſom of its parent-leaf by an adapted ſecretion from the vegetable blood; and continues to be ſo nouriſhed in annual herbs and evergreen trees, till it protrudes and expands its own leaf; but if it be a bud of a deciduous plant, which muſt loſe its parent-leaf in winter, a reſervoir of nutriment is prepared for it in the roots of ſome plants, as in carrots, tnrneps, liquorice, fern; and probably both in the roots and alburnum, or ſap-wood, of trees.

Thus in the ſpring the umbilical veſſels belonging to each individual biennial plant, or bud of a tree, abſorb moiſture from the earth, and propel it upwards through the roots and alburnum, where it is mixed with a nutritious material, and carried upwards in ſome trees with a power equal to the preſſure of the atmoſphere, as in the vine, vitis;

vitis; the birch, betula; and the maple, acer; which at that ſeaſon bleed at every wound, as treated of in Sect. III.

6. At this time the buds begin to ſwell, and to ſhoot roots downwards from their caudexes into the earth; the intertexture of theſe caudexes conſtitutes a new bark over the old one, conſiſting of arteries, veins, and abſorbents, as deſcribed in Sect. I. 3. Each bud then alſo puts forth a leaf, which is a reſpiratory organ, and reſembles in many reſpects the lungs of animals, as deſcribed in Sect. IV. but differs from them in this circumſtance, that the leaf requires light as well as air for the purpoſe of perfect reſpiration, as will be treated of in the Section on Light.

Each embryon of a leaf-bud is thus furniſhed with its proper reſpiratory organ; and as many new embryons were generated during the ſummer in each leaf-bud, they now pullulate in ſucceſſion; each of which has like the firſt its appropriate leaf, which, as they ſucceſſively advance, compoſe the annual ſhoots or ſprigs of trees; which in ſome plants become of great length, as in vines, and willows, conſiſting of twenty or thirty new leaves. Hence if the firſt ſet of leaves be deſtroyed by vernal froſts, as frequently happens to aſh-trees, fraxinus, and to the weeping willow, ſalix babylonica; or by the depredation of inſects, which often injures our fruit-trees; and perpetually occurs in this climate to the ſpindle-tree, euonymus; and in Italy to the white mulberry-tree, which has its firſt leaves plucked off for the food of ſilk-worms, and to the tea-tree in China; a ſecond ſet of leaves ſucceeds, which belong to the ſecond embryons of the ſame bud.

But when the bractes or floral-leaves are deſtroyed by inſects, as ſometimes happens to currant-trees, and apple-trees; the fruit in the pericap does not periſh, like the firſt embryon of the leaf-bud above mentioned; becauſe it is ſtill ſupplied by the abſorbent ſyſtem of the caudex and roots of the flower-bud, which compoſe a part of the bark, and paſs into the ground; but the fruit becomes ſour and leſs perfect from the want of a due oxygenation of the juices, from which it is secreted; though its glands may probably also receive some oxygenated blood by the inosculation of the vessels of different buds, whether flower-buds or leaf-buds, with each other in the bark, on supposition that they are not all of them totally destroyed.

7. In the axilla of each leaf is generally produced about midsummer either a new leaf-bud or a flower-bud; if it be a leaf-bud, it becomes a branch the next year, producing many other leaves, and many other buds; if it be a flower-bud, the growth ceases, terminating in the seed. During the greater vigour of the plant the leaf-buds are solely or principally produced, as in young healthy trees; but when the vessels of the bark become further elongated, as the plant grows taller, the nutritive juices are less copiously supplied, or the buds are become more mature, and the production of flower-buds succeeds as in Mr.Walker's experiments the sap of the birch-tree in the spring was two or three weeks later in ascending to the top of a high tree, than to the lower branches. Edinb. Transact. Vol. I.

Hence it happens, that the grafts from strong seedling apple-trees do not bear fruit, till they are twelve or twenty years old; while the grafts from old weak trees will bear copiously in two or three years, and hence very vigorous trees, as pears, produce fruit only at their extremities; but if you decorticate about an inch of a branch of a vigorous pear-tree, and thus weaken it; that branch will flower, and bear fruit at every bud like trees of less vigour.

It should be here observed, that the words strength and weakness, when applied to the growth of vegetables, are in reality metaphorical terms; or express the effect or consequence of their producing leaf-buds or flower-buds, rather than the cause of it, whereas it is the facility with which the long caudexes of the new buds, which form the new filaments of bark, can be generated, which increases the number of leaf-buds, and gives the tree a luxuriant or vigorous appearance; and the difficulty of generating these new caudexes which

increases

increafes the flower-buds, and thus gives a lefs vigorous appearance to the tree.

The generation of buds feems to require a lefs perfect apparatus than the generation of feeds; as that of buds always precedes that of feeds, both in trees and herbs; and becaufe the caterpillar is converted into a butterfly folely for the purpofe of feminal propagation; whereas the polypus can only propagate laterally, or by buds. Hence the age of the plant is another neceffary circumftance to the production of flowers, fruit, and feeds, as appears in tulips, and hyacinths, as well as in apple-trees and pear-trees.

8. About midfummer the new buds are formed; but it is believed by fome of the Linnean fchool, that thefe buds may in their early ftate be either converted into flower-buds or leaf-buds, according to the vigour of the vegetating branch. Thus if the upper part of a branch be cut away, the buds near the extremity of the remaining ftem, having a greater proportional fupply of nutriment, and poffeffing a greater facility of producing their new caudexes along the bark, will become leaf-buds; which might otherwife have been flower-buds; and on the contrary, if a vigorous branch of a wall-tree, which was expected to bear only leaf-buds, be bent down to the horizon or lower, it will bear flower-buds with weaker leaf-buds, as is much exemplified by Mr. Hitt in his Treatife on Fruit Trees.

The theory of this curious vegetable fact has been efteemed difficult, but receives great light from the foregoing account of the individuality of buds. Both the flower-buds and leaf-buds die in the autumn; but the leaf-buds, as they advance, produce during the fummer other leaf-buds or flower-buds in the axilla of every leaf; which new buds require new caudexes extending down the bark, and thus thicken as well as elongate the branch; whereas the flower-buds fhed their feed, when they perifh in the autumn, and thus require no place on the bark for new caudexes. Hence when the fummit of a branch is lopped off, the buds near the extremity of the remaining ſtem produce new leaf-buds with greater facility, as there is more room for their new caudexes to be generated along the deſcending bark. But if a vigorous branch be bent down to the horizon, or below it, the bark is compreſſed beneath the curve, and extended above it, and thus the production of new caudexes along the bark is impeded, and in conſequence leſs leaf-buds and more flower-buds will be generated, or the former converted into the latter; which require no new caudexes. And on this circumſtance principally depends the management of wall-fruit trees, and of eſpalliers.

For the purpoſe of thus converting leaf-buds into flower-buds Mr. Whitmill adviſed to bind ſome of the moſt vigorous ſhoots with ſtrong wire, and even ſome of the large roots; and Mr. Warner cuts, what he calls, a wild-worm about the body of the tree; or ſcores the bark quite to the wood like a ſcrew with a ſharp knife. Bradley on Gardening, Vol. II. p. 155. Mr. Fitzgerald produced flowers and fruit on ſtandards and wall-trees by cutting off a cylinder of the bark, three or four inches long, and replacing it with proper bandage, (Philoſ. Tranſ. Ann. 1761) as deſcribed in Sect. XV. 1. 3. of this work. M. Buffon produced the ſame effect by a ſtraight bandage put round a branch, Act Paris, Ann. 1738; and concludes that an ingrafted branch bears better from its veſſels being compreſſed by the callus produced, where the grafted ſcion joins the ſtock.

It is cuſtomary to debark oak-trees in the ſpring, which are intended to be felled in the enſuing autumn; becauſe the bark comes off eaſier at this ſeaſon, and the ſap-wood, or alburnum, is believed to become more durable, if the trees remain till the end of ſummer from their expending their ſaccharine ſap-juice in the enſuing foliage, and thus being leſs liable to ferment and putrify. The trees thus ſtripped of their bark put forth ſhoots as uſual with acorns on, the ſixth, ſeventh, and eighth joint, like vines; but in the branches I examined the joints of the debarked trees were much ſhorter than thoſe of other oak-trees; the acorns were more numerous; and no

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new buds were produced above the joints which bore acorns. From hence it appears that the branches of debarked oak-trees produce fewer leaf-buds, and more flower-buds; which muſt be owing to the impoſſibility of their producing new caudexes down the naked branches and ſtem for the embryon progeny of leaf-buds.

The pullulation of leaves on debarked oaks demonſtrates, that the reſervoirs of nutriment depoſited in the preceding ſummer for the uſe of the vernal buds muſt be in this alburnum; and that it is this ſaccharine matter which induces the alburnum to ferment and rot ſooner than the internal wood. Thus Dr. Walker found on nice inſpection the ſap-juice to flow from the ligneous circles of the alburnum as well as between them, when a freſh piece was cut off from a cicatrized part, and alſo between the wood and the bark. Edinb. Tranſact. Vol. I. He alſo obſerved that oak, aſh, elm, aſpen, hazel, and hawthorn, do not bleed; and that the birch, plane, and maple bleed the moſt, and that the grey willow, ſalix caprea, does not bleed, but the ſap-juice riſes viſibly between the wood and the bark, ſo as to make the bark ſeparate eaſily from the wood. From all theſe facts it may be inferred, that the ſaccharine matter, which is diſſolved in the ſap-juice, is depoſited in the autumn in the roots of ſome trees, and in the alburnum of others, or in both; as manna is found in the wood of the manna-aſh; and ſugar in the joints of many graſſes and of the ſugar-cane, and in the roots of liquorice, beets, and many other herbaceous vegetables.

9. About Midſummer, after the new buds appear in the boſom of every leaf, many authors have remarked that there ſeems to be a kind of pauſe in vegetation for about a fortnight, which they have aſcribed to different cauſes. At this time I ſuſpect the reſervoir of nouriſhment for the new buds is forming about the roots or in the alburnum of the tree; and that the caudexes and umbilical veſſels of the new buds are alſo at this time forming down the bark, and terminate in thoſe nutritious reſervoirs in the roots or new alburnum like the

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umbilical veſſels called ſeminal roots, which are viſible in many ſeeds.

That this ſyſtem of umbilical veſſels is poſſeſſed of a great power of abſorption in the roots of trees is certain from the force, with which the ſap-juice was propelled upward from a vine-ſtump in Dr. Hales' experiment. That the ſap-juice thus propelled upwards nouriſhes or expands the leaf of each new bud appears from the experiments of Dr. Walker; as the leaves began to unfold at the ſame height, as the wounded wood began to bleed, and that theſe veſſels paſs through or conſtitute the ſap-wood is evinced by the growth of the buds on oak-trees, after the bark is almoſt totally taken off.

The roots of trees are at this time protruded with greater vigour, as obſerved by the ingenious Mr. Bradley, who on that account prefers the midſummer ſeaſon for tranſplanting trees, if they are not to be removed to any great diſtance; and adds, that the new ſhoots in the following ſpring will put forth with much greater force, and the tree will thence be almoſt a year forwarder in its growth, than if it remains untranſplanted till the winter. Diſcourſes on Earth and Water. This ſeems to be owing to the deſtruction of much of the nutritious matter depoſited in the roots for the uſe of the new buds, which is torn off in tranſplanting, and which can only be replaced about Midſummer or ſoon after.

Mr. Bradley further adds, that when trees are thus tranſplanted at Midſummer, no part of the top or branches, or foliage, ſhould at that time be cut off; which well accords with the theory above delivered; as it is from the vegetable blood, which is oxygenated by its expoſure to the air through the thin moiſt pellicle on the upper ſmooth ſurfaces of theſe leaves, that the nutriment for the expanſion of the buds in the ſucceeding ſpring is ſecreted or produced; and hence if theſe leaves are prematurely deſtroyed, the vernal growth of the buds muſt receive injury; as the reſervoir of future nutriment for them will be leſs in quantity; but if ſome of the branches are lopped

lopped during the winter, the remainder will protrude more vigorous ſhoots, as their ſhare of the reſerved nutriment will be greater.

10. The umbilical veſſels of the new buds of deciduous trees, which are analogous to thoſe which permeate the lobes of the ſeed, are extended downward in the bark about midſummer, and terminate in certain reſervoirs of nutriment, which are at this time ſecreted from the vegetable blood oxygenated in the leaves. This bark now conſiſts of an intertexture of the caudexes of the preſent leaves, which were buds in the laſt ſummer, and are now adult vegetable beings; and of the embryon caudexes of the new buds; and of the umbilical veſſels of the new buds; it will become alburnum or ſap-wood during the autumn or enſuing ſpring, and will be gradually covered over with a new bark conſiſting of the mature caudexes of the new buds, while that, which was the alburnum in the preceding ſpring, will become a circle of lifeleſs timber, interior to the circle of alburnum.

The veſſels of this new bark, though they conſiſt of the caudexes of the individual adult leaves, and the umbilical veſſels of the individual young buds, evidently inoſculate; becauſe, when ſome buds are rubbed off or deſtroyed, thoſe in their vicinity grow with greater vigour; as the daily experience of pruning all kinds of trees evinces. The facility with which the ruptured veſſels of vegetables inoſculate into each other, or grow together, correſponds with that of animal veſſels in their inflamed ſtate. Thus a bud taken from one tree, and inſerted into any part of the bark of another tree of the ſame genus, or ingrafted on it, preſently receives nutriment, and grows to it by the reciprocal inoſculation of the wounded veſſels, in the ſame manner as a tranſplanted tooth; or as the fingers are liable to grow together after having been excoriated by a burn; or as the inflamed lungs and pleura are liable to adhere, and intermix their blood-veſſels. See Sect. III. 2. 7.

During the winter, when the leaves die and fall off, the arterial and venous ſyſtems, which belonged to them, and which compoſed the

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greateſt part of the bark, ſeem to loſe their vegetable life at the ſame time, and to coaleſce, and form the alburnum, or ſap-wood ; but the umbilical veſſels belonging to the new buds, which are intermixed with this alburnum, remain alive ; and at the returning ſpring act with aſtoniſhing vigour ; as deſcribed in Sect. III. 2. 2.

As the ſpring advances, the umbilical veſſels, after having drank up the reſervoirs of nutriment, which were depoſited about the roots, and having thus nouriſhed and expanded the new leaves, ceaſe to act ; and the alburnum gradually changes into hard wood, called the heart of the tree ; which no longer poſſeſſes vegetative life ; and is now only uſeful to elevate and ſuſtain aloft the ſwarm of biennial plants, which cover it ; and was probably originally produced for this purpoſe in the conteſt of all vegetables for light and air.

This inert or lifeleſs ſtate of the central parts of trees, called the heart-wood, is evident from thoſe old oaks and willows, which have loſt their internal hard wood, and are become quite hollow, conſiſting only of their bark and alburnum, and yet are furniſhed with many healthy branches. But the umbilical veſſels of the alburnum poſſeſs the properties of capillary tubes, or of a ſponge, after they are extinct, and ceaſe to act as umbilical veſſels ; and thus may occaſionally attract moiſture, or ſuffer it to paſs through them mechanically ; whilſt the new bark, which conſiſts of an intertexture of the caudexes of each bud with their radicles, may occaſionally abſorb this moiſture from the capillary veſſels of the alburnum, which may be compared to the upper ſtratum of the ſoil attracting by capillary power the moiſture from the ſoil immediately beneath it, which may exhale into the atmoſphere, or be imbibed by the roots of vegetables by the ſuperior living power of their abſorbent mouths.

That the veſſels of the alburnum in their living ſtate poſſeſs the property of conveying the ſap-juice, which is propelled upwards in the early ſpring by the abſorbent terminations of the roots, is viſible in decorticated oaks ; the branches of which expand their buds, like thofe of the birch and vine in the bleeding feafon. That the veffels of the alburnum in their living ftate occafionally act as capillary fyphons, through which the fap-juice is firft pufhed upwards by the abforbent extremities of the roots, and afterwards returns downwards partly by its gravitation in branches bent below the horizon, appears from an experiment of Dr. Walker, mentioned in Sect. III. 2. 4.

Laftly, that the veffels of the alburnum after their vegetable life is extinct, poffefs a power of capillary attraction of the fap-juice, or of permitting it to pafs through them occafionally, appears from the following experiments. Firft, a branch of a young apple-tree was fo cankered, that the bark for about an inch quite round it was totally deftroyed. To prevent the alburnum from becoming too dry by exhalation, this decayed part was covered with thick white paint; in a few days the painting was repeated, and this three or four times, fo as to produce a thick coat of paint over the decayed part, or naked alburnum, extending to the afcending and defcending lips of the wound; this was in fpring, and the branch bloffomed and ripened feveral apples.

In a garden in Lichfield about four years ago a complete cylinder of bark about an inch long was cut from a branch of a pear-tree nailed againft a wall; the circumcifed part is now not more than half the diameter of the fame branch above and below it; yet this branch has been full of fruit every year fince, when the other branches of the tree have borne only fparingly. I lately obferved, that the leaves of this wounded branch were fmaller and paler, and the fruit lefs in fize, and ripened a fortnight fooner, than on the other parts of the tree. Another branch of the fame tree has a part of the bark taken off about an inch long, but not quite all round it, with much the fame effect.

The exiftence of capillary tubes in dead fap-wood is vifible in a piece of dry cane, which permit water or fmoke to pafs through them; and in the exhaufted receiver of an air-pump both water and quickfilver may be made readily to pafs through pieces of the dry alburnum of wood by the preffure of the atmofphere.

11. The flower-buds of many trees arife immediately from the laft year's terminal fhoots, or fpurs, either accompanied with leaf-buds, or feparately, as in apple and pear-trees. Other flower-buds arife from the fhoots of the prefent year alternately with leaf-buds, as thofe of vines, and form the third or fourth buds of the new fhoots. They differ from leaf-buds in this circumftance, that they perifh when their feeds are ripe, without producing any addition or increafe to the tree; whereas when the leaf-buds perifh in the autumn, their caudexes, the intertexture of which conftitutes the bark of the tree, gradually become converted into alburnum, or fap-wood; over which the new leaf-buds fhoot forth their caudexes and radicles, or infert them into it, and gradually fabricate the new bark and root-fibres.

It was before mentioned, that it is believed by fome difciples of the Linnean fchool, that about Midfummer leaf-buds may be changed into flower-buds, or flower-buds into leaf-buds; and that even after the vegetable embryons are generated. And that this may be effected by weakening or ftrengthening the growth of the laft year's buds, which fecrete thefe new ones from the vegetable blood, and nourifh them in their infant ftate. Thus if fome inches of the extremity of a branch be lopped off at Midfummer, as is fometimes done by unfkilful gardeners, the remaining few buds will become more vigorous, and confequently produce leaf-buds inftead of flower-buds; or perhaps the embryons already formed may be converted from one kind to the other. The contrary may occur, if a vigorous branch of a wall-tree be bent down beneath the horizon, or fo much as to impede the generation of new caudexes; or if the leaf of the parent-bud be taken off, foon after the plumula or apex of the new bud is generated; and thus the new caudex along the bark may be prevented by deficiency of nutriment.

The probability of this idea of tranfmuting flower-buds and leaf-

buds

buds into each other is confirmed by the curious converfion of the parts of the flowers of fome vegetable monfters into green leaves; if they be too well nourifhed, after they are fo far advanced as to be unchangeable into leaf-buds. Thus in the plantago rofea, rofe-plantain, the divifions of the fpike become wonderfully enlarged, and are converted into leaves; the chaffy fcales of the calyx in xeranthemum, everlafting, and in a fpecies of dianthus, pink, and the glume of fome alpine graffes, and the fcales in the ament of the falix rofea, rofe-willow, grow into leaves, and produce other kinds of vegetable monfters.

Add to this, that the petals of the helleborus niger, or chriftmas-rofe, are beautifully white till the feed is impregnated; and then they change into green leaves, forming a calyx. And laftly, in other flowers a bud or bulb fucceeds the impregnation inftead of a feed, as in polygonum viviparum, viviparous biftort; and in allium magicum, magical onion; the fame occurs in many of the alpine graffes, and in the feftuca dumetorum, fefcue grafs; all which are in fome degree analogous to the fuppofed converfion of early flower-buds into leaf-buds; for in thefe magical onions, and other bulbiferous flowers, the bractes or floral-leaves, which at firft fecrete nourifhment for the pericarp and feeds of the plant, affume a new office, and fecrete a magazine of nourifhment for the new bulb, as appears in the concentric flefhy membranes, which furround the new fummit-bulbs of the allium magicum, and the cloves of garlic.

12. The central part of an adult bud therefore confifts firft of a conjunction of the blood-veffels from above and below, which exifts in the caudex of the bud between the beginning of the leaf-veffels and the beginning of the root-veffels; the circulation refembling that of many infects, of fifh, and in the livers of quadrupeds, as fhewn in Sect.V. 2. Secondly, there is probably at the fame place a conjunction of the abforbent veffels correfpondent to the receptaculum chyli of animals. Thirdly, there exifts in each bud an organ

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of reproduction, which in a leaf-bud produces the lateral or paternal offspring, and in a flower-bud the seminal or amatorial one. Fourthly, a center of nervous influence, as a brain, or spinal marrow, or common sensorium, exists in each bud; and probably resides near this junction of the blood-vessels of the leaf and root, and of the absorbent system, along with the organ of reproduction in the caudex gemmæ.

III. 1. The bulbous roots of some perennial herbaceous plants, and the root-scions of other perennial herbaceous plants, are similar in this respect, which distinguishes them from buds; that they are generated on the broad caudex of the plant within the ground, or in contact with it, and immediately shoot down their new roots into the earth. Whereas buds are formed above the soil on the long caudexes, which constitute the filaments of the bark of trees, and shoot down new roots into the earth from the lower end of these elongated caudexes.

Bulbs have not improperly been called subterraneous buds; and like them they may be divided into leaf-bulbs and flower-bulbs. When a tulip-seed is sown, it produces a small plant the first summer, which in the autumn dies, and leaves in its place one or more bulbs. These are leaf-bulbs, which in the ensuing spring rise into stronger plants than those of the first year, but no flowers are yet generated; in the autumn these perish like the former, and leave in their places other leaf-bulbs stronger, or more perfect, than their preceding parents. This succession of leaf-bulbs continues for four or five years, till at length the bulb acquires a greater perfection or maturity, necessary for seminal generation, and produces in its place a large flower-bulb in the centre with several small leaf-bulbs around it.

This successive formation of leaf-bulbs in bulbous rooted plants previous to the formation of a flower-bulb is curiously analogous to the production of leaf-buds on many trees for several years before the production of flower-buds; thus the apple-trees, pyrus malus, which are raised from seeds, generate only leaf-buds for ten or twelve years, and

and afterwards annually generate both flower-buds and leaf-buds. From whence it would ſeem, that the adherent lateral or paternal progeny is the moſt ſimple, and eaſieſt, and conſequently the firſt mode of reproduction; and that the amatorial or ſeminal progeny is on this account not generated till the maturer age or more perfect ſtate of the parent-bud.

A ſtill more curious analogy to this circumſtance of a ſucceſſion of leaf-buds and leaf-bulbs preceding the formation of flower-buds and flower-bulbs exiſts in the growth of wheat, triticum, and other graſſes; but with this difference, that a ſucceſſion of leaf-buds, as of two, or three, or four, are produced in the ſame year previous to the flower-bud. At the firſt joint of the ſtem of wheat, on or within the ſurface of the earth, a leaf is produced; from which riſes the principal or central bud, and around it many new buds, which ſtrike their roots into the ſoil. After this central bud, and thoſe around it, have ariſen ſix or eight inches, a new leaf and a new leaf-bud riſes on each of them, producing a ſecond joint of the ſtem; and laſtly, a flower-bud is generated at the ſummit, which are all evidently diſtinct vegetable beings, as there is a diviſion acroſs the ſtem at each joint, which ſhews there is no connexion of the pith, or brain, or ſpinal marrow, between the lower and upper joints, as mentioned in Sect. I. 8.

That a new bud thus conſtitutes each joint of the ſtem of wheat, and other graſſes, is further evinced; firſt, by the exiſtence of a leaf at each joint without a lateral bud in its axilla, as occurs in other vegetables. Secondly, becauſe for the nouriſhment of this new leaf-bud a reſervoir of ſweet-juice is prepared in the new joint; as in the bulbs of many plants. And thirdly, becauſe the lower leaf dies, and the ſweet juice is abſorbed, as the upper leaf becomes vegete. Hence we acquire the knowledge of the uſe of this reſervoir of ſugar in the vegetable economy, which ſupplies ſo much agreeable and ſalu-

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tary nouriſhment to mankind from the cultivation of the ſugar-cane. See No. 1. 6. and No. 3. 7. of this Section.

The analogy between the buds of plants and the adherent lateral progeny of ſome inſects, as of the polypus, and tenia, or tape-worm, and volvox, was mentioned in Sect. VII. 1. 4. But the circumſtance of the ſucceſſive production of leaf-buds and leaf-bulbs previous to the production of flower-buds or flower-bulbs is wonderfully analogous to the generation of the aphis, which riſing from an egg in the ſpring after caſting its ſkin once or twice produces a living progeny without amatorial copulation; and this offspring produces others by this ſolitary propagation till the tenth generation; then a ſexual progeny of males and females is produced, and eggs are laid in the autumn from their amatorial intercourſe. Encycloped. Britan. Amœnitat. Academ. Vol. VII. by A.T. Bladh. See Sect. XIV. 3. 2. Thus this inſect from the egg requires to be reproduced many times by ſolitary propagation before it becomes ſufficiently perfect to generate a ſexual offspring like the buds and bulbs from ſeeds above mentioned. And it is probable, that the polypus of our ſtagnant waters, which produces a lateral offspring in the ſummer, I ſuppoſe by ſolitary propagation, may produce males and females, and generate eggs in conſequence in the autumn for their reproduction in the enſuing ſpring.

To this may be added the great change, which many inſects and even larger animals undergo either in ſtrength or form, before they acquire the power of ſeminal reproduction. As the ſilk-worm changes into a butterfly apparently for the purpoſe of generation only, as it then performs this office and dies. Other caterpillars change their form likewiſe into butterflies, and at the ſame time change their kind of food, which was the green foliage of vegetables before this tranſformation; but now conſiſts ſolely of honey. And laſtly, the gnat and muſqueto change at the ſame time both their forms, their food, and their element; and thus acquire higher animation apparently for the purpoſe of ſexual reproduction.

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2. The manner of the production of herbaceous plants from their various perennial roots wants further inveſtigation, as their analogy is not yet clearly aſcertained. I this autumn diſſected two large roots of the onion or leek kind, which were in full flower; the ſtem of each of them was embraced by the cylindrical pedicles of ſix or ſeven concentric leaves; but the ſtem itſelf aroſe from the center between three large new bulbs in one of them, and between two in the other. All of which grew from the ſame caudex, but the central flower-ſtem was wrapped at its bottom in one membrane only, which ſeparated it from the new bulbs in its vicinity.

A large root of a young onion, which grew from ſeed ſown in the ſpring, was at the ſame time diſſected by ſtripping off the leaves, and their fleſhy baſes, one after another, till two buds were viſible in the center of the fleſhy baſes of the concentric leaves, which formed the bulb. Theſe two bulbs were evidently formed and nouriſhed on the caudex by the ſtem, and its ſix or ſeven concentric cylindrical leaves; and will, I ſuppoſe, ſeparate in the ſpring, as they riſe up, and produce each of them a flower with two or three new bulbs at the baſe of it, as deſcribed in the above paragraph.

Or from the different ſize and apparent greater maturity of the central bulb, and the ſecondary bulb being between the innermoſt and the ſecond circular fleſhy membrane, I ſuppoſe in theſe roots of onion, like the tulip-roots before ſpoken of, that the central bulb alone may produce a flower in the next ſummer; and that the lateral bulb or bulbs will produce only ſtronger and more mature leaf-bulbs, which will in the ſucceeding ſummer bear a flower or ſexual progeny.

The caudex, or central part of the bulb, from which the root-fibres deſcend, and the leaves aſcend, lies above the knot in the orchis morio; and the parent-root ſhrivels up and dies, as the young one increaſes. The flower of this plant does not ripen its ſeeds in this climate; it might be otherwiſe worth cultivation for the uſe of the new roots; which when ſcalded and peeled, are ſaid to be the ſalep of the ſhops. It is aſſerted by one of the Linnean ſchool in the Amœn. Academ. that if the new root be pinched off, the ſeeds on the old one will ripen, and become prolific.

In the tulip the caudex lies below the bulb, from whence proceed the fibrous roots and the new bulbs; the root after it has flowered dies like the orchis root; for the ſtem of the laſt year's tulip lies on the outſide, and not in the center of the new bulb. In the tulip-root, diſſected in the early ſpring, juſt before it begins to ſhoot, a perfect flower is ſeen in its center; and between the firſt and ſecond coat the large next year's bulb is, I believe, produced; between the ſecond and third coat, and between this and the fourth coat, and perhaps further, other leſs and leſs bulbs are viſible, all adjoining to the caudex at the bottom of the mother bulb; and which I am told, require as many years, before they will flower, as the number of the coats with which they are covered; and that the ſame different ſtates of maturity probably obtain in the buds round the ſhoots of many fruit-trees, the central one of which will produce flowers the next year as on the ſpurs of apple-trees; while thoſe beneath it require more or fewer years, before they become ſufficiently mature to produce organs of ſexual generation; an important ſecret in the management of fruit-trees.

The hyacinth-root differs from the tulip-root; for, as I am informed, the ſtem of the laſt year's flower is always found in the center of the root, as in the onions above deſcribed; and that the new offſets ariſe from the caudex below this bulb, and not between any of the concentric coats of it, except the two external ones. On this account the central part is liable by its decay to deſtroy the flower-bud, if not taken out of the earth, when the leaves die; and hence ſome floriſts believe, that theſe roots periſh naturally in five or ſeven years, after they have flowered, but that the tulip-root never dies from age.

In

In a few roots of hyacinths, which I this day examined, September 1, the ftem of one, which had apparently flowered in the fummer, was perfectly decayed in the center of many new bulbs. In another bulb of lefs fize and compact, which I fuppofed had not born a flower, I found a central flower-bud inclofed in many concentric flefhy bafes of former leaves, like an onion in the autumn, which had been fown in the preceding fpring. And concluded from hence, that the hyacinth-root dies annually or biennially like the onion, leaving behind it a fucceffion of leaf-bulbs or of flower-bulbs.

The caudex and claw-like roots of the ranunculus cultivated by florifts dies I believe annually, after having put forth a circle of new claws from the upper part of it round the bottom of the perifhing flower-ftem. Hence the claws of the old root, which became fhrivelled, as the flower advanced, in the autumn difappear; and the decayed part of the old caudex is feen beneath the new claw-like roots, which I fuppofe has given occafion to fome inaccurate obfervers to believe, that the old ftem in this and fome other perennial herbaceous plants was drawn downwards by the new root fibres; while the bulbs of the iris have been fuppofed to have been pufhed upwards, like the lamb-like barometz, by the refiftance of the foil to the elongation of the root-fibres; which laft feems to be a much more probable idea than the former.

From thefe obfervations it appears, that the concentric leaves, which incircle the ftems of bulb-rooted plants, are the lungs to the caudex, as one or more leaves are to the bud of a tree; and that the caudex with thefe leaves, and the root-fibres, conftitute a vegetable being; which produces a viviparous progeny of new leaf-bulbs, or a feminiferous progeny in flower-bulbs, with a magazine of nutriment in the flefhy bafe of each leaf; and that the tulip produces only leaf-bulbs for four or five years from the feed, and then but one flower-bulb with many leaf-bulbs annually. But that the onion-kind, allium, generates two or three flower-bulbs in the firft fummer from the feed; which produce flowers and other leaf-bulbs in the fecond fummer from the feed. And laftly, that it is probable, that all bulbous roots, like the buds of deciduous trees, and perhaps of evergreen ones alfo, are properly fpeaking biennial plants, as they rife in one fummer and perifh in the next.

3. In tulip-roots, which have been planted too deep in the earth, and in onion-roots, a vegetable cord, or procefs, is fometimes feen about an inch long to arife from the caudex beneath the bafes of the cylindrical leaves, and to form a new bulb. Similar to this appears the natural growth of the roots of potatoes; a fpermatic cord arifes from the old root, after the leaves are expanded in the air, to oxygenate the vegetable blood, and a new tuberous or bulbous root is thus generated.

This mode of producing diftant roots is exactly refembled above ground by the wires of ftrawberries; which may be called fpermatic cords, which depofit a new vegetable being on the earth, and fupport it like a bud on a tree, till it can ftrike roots into the foil, and elevate leaves into the air. The final caufe of the length of thefe fubterraneous and aerial fpermatic cords is evidently the defign of placing their roots at a convenient diftance from their parent plants; that they may not incommode each other, but may both of them more readily acquire nutritious juices from the earth, and the ventilation and funfhine of the atmofphere.

Thefe embryon vegetables in the various bulbous and tuberous roots are in very different ftates of maturity, as in the buds of different trees; thus in the potatoe the corculum or plumula of the new plant only is vifible, furrounded with a farinaceous nutriment, as in many feeds; whereas in the tulip and hyacinth the flower of the fucceeding year is difcernible, as in the bud of the horfe-chefnut.

As the ripening of the feed of fome bulbous-rooted plants is forwarded by deftroying the new bulbs, as in orchis; and the flowering bulbs of other plants are made ftronger by raifing them out of the earth,

earth, and taking away the leaf-bulbs, which ſurround them on the ſame caudex; as in the cuſtomary management of tulip-roots, and hyacinth-roots by the floriſts; I was led to ſuſpect, that pinching off the flowers of potatoes two or three times might increaſe the ſize or quantity of the roots; as the nouriſhment derived from the vegetable blood to the flowers and ſeeds might thus be directed to enlarge the roots, and thus lay up more nutriment for the future plants. This idea I mentioned to an ingenious Lady, who acquainted me a few months afterwards, that on a few roots ſhe had made this experiment with apparent advantage.

4. The bulbous and tuberous roots of plants are a lateral or paternal progeny like the buds of trees, and therefore exactly reſemble the parent plant, as mentioned in Sect. III. 2. 1. and on this account may be liable to be affected by hereditary diſeaſes, and thus to become unhealthy; whence the canker is ſuppoſed to ariſe in thoſe apple-trees, which have for a century or two been propagated by grafting; and the curled leaf in potatoes, which have been too long propagated by their bulbs; and the barrenneſs of hautbois ſtrawberries, which have too long been propagated by wires; all which diſeaſes are believed not to happen in theſe plants, if they have recently been raiſed from ſeed, but want further obſervations to authenticate the facts.

But there exiſts a ſet of bulbs, which ſeem to be formed by amatorial or ſeminal generation, and not by the lateral or paternal generation, and would therefore ſeem to be a viviparous ſexual progeny. Theſe are produced on the flower-ſtem in the place of ſeeds; and in proceſs of time fall off, and take root in the earth, as is agreeably ſeen in the polygonum viviparum, viviparous biſtort, and the magical onion, allium magicum, and the leek, allium ſativum. A curious queſtion here occurs, whether the plants from theſe bulbs are liable exactly to reſemble their parents? and whether they would be liable to hereditary diſeaſes from a long cultivation of them in ſucceſſion, as is ſuppoſed to happen to thoſe mentioned above?

Though

Though a perfect flower precedes the product of ſome ſummit-bulbs, as I believe in the lower part of the ſpike of the polygonum viviparum; yet I ſuſpect, that the ſummit-bulbs of allium magicum, are exactly ſimilar to the bulbs, which are produced at their roots; becauſe on cutting one of them horizontally into two hemiſpheres this morning, September 10, I obſerved three young bulbs incloſed in the concentric fleſhy membranes of the ſummit-bulb in the following manner; five thick fleſhy concentric coats of the general ſummit-bulb being taken away, there appeared one ſingle naked ſmall bulb; and on the ſixth coat being removed, two other bulbs became viſible, which were included in it. Whence it ſeems, that theſe ſtem-bulbs are as forward as thoſe of the root, and probably are in every reſpect ſimilar; and that the bractes or floral-leaves, which in ſeed-bearing plants ſecrete or prepare a nouriſhment for the ſeed, and pericarp of the flower, acquire in theſe bulbiferous onions and leeks a new office, and prepare a magazine of nouriſhment in the concentric membranes, which ſurround their ſummit-bulbs; and theſe may be eſteemed therefore a ſexual viviparous progeny of vegetables, as buds are a lateral viviparous progeny.

5. The roots of trees ſo reſemble their branches, that ſubterraneous buds are frequently produced upon them, which reſemble the parent-tree. The bark of the root likewiſe ſo reſembles the bark of the branches, that it is not uncommon to ingraft with ſucceſs on roots taken out of the earth and replanted; as the robinia on the root of the acacia, and any other apples on the roots or the ſuckers of bur-apples or of codlings; which may be done earlier in the vernal months, as being leſs liable to injury from froſty nights; and it is probable, that budding or inoculating may be performed in the ſame manner on the roots at midſummer, as on the branches.

The roots of thoſe plants, which are otherwiſe not eaſily propagated, will ſhoot up buds, if a part of them next to the plant be half cut through, or raiſed out of the ground, and expoſed to the air; as in pyramidal campanula, and geranium lobatum ; and after a time the root may be ſeparated from the ſtock, and many new plants may be this way produced.

Theſe root-buds, or ſuckers, are generally produced near the trunk of the tree, before the root deſcends much beneath the ſoil ; but in ſome trees, as the elm, ulmus, and acer, maple, whoſe roots ſpread far horizontally, and near the ſurface of the earth, they are generated at a great diſtance from the parent tree ; becauſe the new ſcion can thus ſoon acquire the influence of the atmoſphere on its expanding foliage. Theſe root-ſcions from apple-trees are frequently uſed in vegetable nurſeries for the purpoſe of ingrafting upon, and are termed paradice-ſtocks by ſome gardeners ; but are not liable to the canker like the grafts from thoſe old apple-trees, which have been in faſhion above a century ; as theſe root-ſcions reſemble the trunk of the tree, which produces them, not the ingrafted head of it ; and thus may not have been many years from the ſtate of a ſeedling vegetable.

Similar to theſe root-ſcions of trees it is probable, that the root-buds of perennial herbaceous plants are produced ; which have divaricated, or fibrous-roots, and whoſe ſummits periſh in the winter. For many years the root thickens by an annual new bark being induced over the old one, exactly as in the trunks and roots of trees.

As theſe roots increaſe in ſize, the central part, I ſuppoſe, changes like the internal wood of a tree, and ceaſes to poſſeſs vegetable life ; and in proceſs of time is liable to decay. On this account theſe perennial roots are not ſo valuable for the purpoſes of medicine or diet, or mechanic arts, either before or after they have paſſed a determinate age ; as the bark of the root changes annually into a kind of alburnum, and then into a kind of wood, and laſtly, is liable to decay, as occurs in the roots of rheum palmatum, when they are ſeven or more years old. See Sect. XVII. 2. 1. This decay of the central part of the root, which happens annually to ſome plants, and is ſurrounded with new buds and their root-fibres, exhibits the appearance of the lower end of the root having been chopped, or bitten off, to ſome fanciful botaniſts; as in plantago major, and valerian; and has hence given to ſcabioſa ſucciſa the name of devil's-bit, morſus diaboli.

6. The bulbs already mentioned, as thoſe of tulips, hyacinths, and onions, are properly the winter-cradles, or hybernacula, of the young plants, whether in their leaf-bulb or flower-bulb ſtate; and are furniſhed with a magazine or reſervoir of nouriſhment for the growing embryons, as appears in the ſquil, ſcilla maritima, which vegetates from this ſource of nutriment in the druggiſts ſhops. But there are other roots termed tuberous roots, as of turnep and carrot, which conſiſt ſolely of a large reſervoir of nutriment for the growth and nouriſhment of the riſing ſtem and future ſeeds; whether theſe are produced in the ſame year, as occurs, when the ſeeds are ſown early in the ſpring; or when their vegetation is ſtopped by the cold of winter, and proceeds again in the enſuing ſpring; as generally occurs to our turneps, the roots of which I am well informed may be much enlarged by tranſplantation. See Sect. XII. 6.

In theſe plants the leaves, by expoſing the vegetable blood to the influence of the air, prepare it for the ſecretion of nutriment in their knobby roots; in the ſame manner as nouriſhment is produced and reſerved in the concentric fleſhy baſes of the leaves of onions; and in theſe plants, as in the onion kind, the leaves, which ſurround the baſe of the new ſtems, wither and die; as the new buds, or bulbs, put forth leaves of their own for the purpoſe of oxygenating their blood. Thus it appears, that the ſtem and flower of the onion, or carrot, or turnep, is a new plant, not ariſing immediately from the ſeed which was ſown, but from the leaf-root or leaf-knob, if it may be ſo called, which preceded the production of the flower-bud, or flower-ſtem, exactly as the flower or ear of wheat, which was ſhewn in Sect. IX. 3. 1. to have three or four ſucceſſive leaf-buds preceding the flower-bud.

From theſe obſervations may we conclude, that no flower-bud or flower-

flower-bulb is ever produced from a ſeed, without the previous interpoſition of one or more leaf-buds or leaf-bulbs? and that thoſe flower-buds or flower-bulbs are either produced in one generation after ſowing the ſeed, as the flower-bulbs of onions, which are generated and nouriſhed at the baſes of the concentric cylindrical leaves of the preceding leaf-plant, which aroſe from the ſeed; or as the ſtems and flower-buds of the carrot and turnep, which are generated and nouriſhed at the baſe of the concentric leaves of the preceding leaf-plant. Or ſecondly, that they are produced in one ſummer, though after ſeveral generations from the ſeed; as the three or four joints of the ſtem of wheat, and other graſſes, which are generated and nouriſhed in ſucceſſion in the boſoms of four or five cylindrical leaves, one at each joint; which alſo probably obtains in all other vegetables, which are ſupported by hollow ſtems divided by joints, and furniſhed with leaves at theſe ſtem-joints with or without branches, as tragopogon or picris. In theſe plants, where there are no branches, there is ſimply a new central bud; and two or more lateral new buds beſide the central one, where there are branches.

Or laſtly, where the leaf-buds or leaf-bulbs, which are produced from ſeeds, ſucceed each other for ſome years, before they arrive at ſufficient maturity to produce ſexual organs, or generate a flower, as in the bulbs of tulips, and hyacinths, and the buds of trees. Whence we at length acquire a diſtinct idea, why ſeedling apple-trees are ten or twelve years before they bear fruit; though the buds or ſhoots taken from a tree, which already has born fruit, and ingrafted even on a young ſeedling-tree, ſhall produce flowers in the firſt or ſecond year; as theſe buds have already acquired that ſtate of perfection or maturity, which is neceſſary to the production of ſexual or ſeminal generation: and as it therefore poſſeſſes the age of puberty, or the maturity of the tree; we may ſuſpect, that it will ſooner acquire the hereditary diſeaſes conſequent to too long unmixed ſucceffive generations, a piece of very important knowledge to the planters of orchards; which they owe to the obfervation of Mr. Knight, as mentioned in Sect. VII. 1. 3.

Hence in many plants produced from feeds, perhaps in all, one or more leaf-buds precede the flower-bud; and I fuppofe generally, if not always, a magazine of aliment is formed at the bafes of the leaves, or in the roots, for the nutriment of the fucceeding leaf-bud or flower-bud, of which it is the parent.

Thus in the carrot and turnep the firft leaves conftitute the lungs of the new vegetable being, which generates the fucceeding flower-ftem, and fecretes or depofits for it a magazine of aliment, which forms the tuberous root: and then this firft plant from the feed and its leaves or lungs perifh; and the root gradually fhrivels up, as it is abforbed by the new flower-ftem. In many plants thefe firft or root-leaves differ in form from thofe of the fucceeding ftem, as in palmated rhubarb, and in campanula rotundifolia, which is fo called from the round form of the leaves of this firft leaf-bud, or root-plant, which precedes the flower-ftem.

7. One great advantage of Mr. Tull's horfe-hoeing hufbandry, in which the earth near the rows of wheat is alternately turned from and to them during the vernal months, has been fuppofed to arife from fome fibres of the roots being thus cut off, and new ftems fhooting up at the ends of thofe which remain; but the real caufe of the production of the new ftems is from the accumulation of earth above the firft joint of the young wheat-plant; from which the new buds fpring out, generated and nourifhed by the caudex of the leaf, which furrounds that joint, and which afterwards withers; this important circumftance is fhewn by the annexed delineation of a tranfplanted wheat-plant.

The plant of wheat was taken from a corn-field in the fpring, and then confifted firft of the root immediately proceeding from the feed

feed *a*, which has been called the feminal root; and fecondly, of the root, which was then near the furface of the ground *b*, which has been called the coronal root, was furnifhed with a ftem and leaf, *c*, *d*, and with a fecondary ftem, or root-fcion, *e*, *f*. This wheat-plant confifting of only two ftems was replanted in my garden, and purpofely buried fo deep as to cover the two or three firft joints of both the ftems beneath the foil; that is as high as the letter *f*, where the fecondary ftem was purpofely cut off.

On taking up this plant with fome others on September 24, it had affumed the form here delineated. The primary ftem, *c*, *g*, had fhot out no new roots from the joint *g*, which I fuppofe to have happened from its being too far advanced when replanted; as many other ftems of other wheat-plants, which had not been obtruncated, had neverthelefs put forth one or more lateral ftems or root-fcions at the fecond or third joints, which on tranfplantation had been covered with the foil.

But the obtruncated ftem, *e*, *f*, had generated a new root-fcion at *h*, like the firft fhoot from the feed at *a*; which had produced other new ftems, as it approached nearer the furface of the earth at *i*; and as thefe advanced into the air, and formed their leaves, other new root-fcions were generated at *k* and *l*. Whence it appears, that by decapitation, and a deeper immerfion in the ground, a fecondary ftem in this plant became multiplied into five; all which produced perfect ears of corn; and in other roots, which I had planted in a fimilar manner, the increafe was much greater: and efpecially where one or more of the primary or fecondary ftems had been decapitated.

If a grain of wheat be dropped on the furface of the earth, and fuffered to fhoot down its roots, and to raife its ftem, which is the procefs of nature, I fuppofe but one ftem would be produced; as the firft knot or joint of it would not be covered with earth, and could not therefore ſhoot down new roots; which are neceſſary in theſe plants to the production of new ſtems, which are not branches but ſuckers or root-ſcions.

But if the grain be buried an inch deep in the earth, a ſhoot riſes from the roots, which iſſue from the ſeed, which is an elongation of the caudex, and puts forth a leaf in contact with the ſurface of the earth; this leaf and ſtem conſtitute the primary plant, and generate new buds, which put forth new roots deſcending into the earth; and thus three or four or more ſuckers, or new plants, ariſe round the original one, which was contained in the ſeed: hence the appearance of two roots, which ſome authors have named the ſeminal and coronal roots. The ingenious Mr. Tull ſeems himſelf to have been aware of this circumſtance, as he ſays in his Huſbandry, "Late planted wheat ſends out no root above the grain before ſpring, but is nouriſhed all winter by a ſingle thread proceeding from the grain up to the ſurface."

This explains the prodigious multiplication of the ſtems of wheat, which may be produced by tranſplanting it three or four times in the ſummer, autumn, and enſuing ſpring; for if it be ſo managed, that a ſecond joint of each young ſtem be buried in the ſoil, or brought even into contact with it, ſo that new roots may ſtrike down into the earth; the caudex of the leaf, which ſurrounds this joint, will generate many new buds, which will thus become ſuckers, or root-ſcions, and rival their parent; and may be again tranſplanted or earthed up three or four times with wonderful increaſe. Mr. Charles Miller of Cambridge ſowed ſome wheat on the ſecond of June 1766, and on the eighth of Auguſt one plant was taken up and ſeparated into eighteen parts and replanted; theſe plants were again taken up and divided between the middle of September and the middle of October, and again planted ſeparately to ſtand the winter, and this ſecond diviſion produced ſixty-ſeven plants. They were again taken up, and divided between the middle of March and the middle of April, and produced five hundred plants. The number of ears thus produced from one grain of wheat was 21109, which meafured three pecks and three quarters of corn, weighed forty-feven pounds feven ounces, and were eftimated at 576840 grains! Philof. Tranf. Vol. LVIII. p. 203. See Sect. XII. 6.

Nor is this unfupported by the analogy of other vegetables, in which new roots are liable to fhoot in great abundance from their joints either alone or along with new buds, if a proper degree of moifture is prefented to them. Thus if the ftem of a potatoe be laid down upon the earth, and covered with foil over the firft joint, a new feries of roots will be protruded from that joint; and afterwards another feries of roots from the fecond joint, if managed in the fame manner; and it is afferted that this will occur even if the potatoe ftems are taken out of the ground, when they are fix or eight inches high, and deprived of all their young roots, and tranfplanted, fo as to cover one or two joints, and that a great crop has been thus produced.

The rapid growth of fome graffes, and of fome fpecies of the convolvulus, and of colt's-foot, is well known, and very troublefome in many fituations. Of thefe very minute parts of the jointed root, when cut from the parent, elongate themfelves, and fhoot up new plants. From the very numerous divifions of the wheat-root defcribed by Mr. Miller, it may be fufpected that fomething fimilar to this muft have happened, which further obfervations muft determine.

Vines alfo are thus liable to fhoot out roots at their joints, and fig-trees, when covered only with a fhred of cloth in nailing them to a wall, if it be accidentally kept moift. And there is an apple-tree, which is called a burr-apple, becaufe it puts out roundifh protuberances or excrefcences of the bark like a burr, which if the branch be bent down, or even torn off, and fet in the moift earth, will

will immediately ftrike out roots, as I am told, and become a tree fimilar to the parent.

In the fame manner I have been informed that if a circular ring of the bark be cut off from many trees and fhrubs, which are otherwife difficult to propagate, and earth be put round the branch thus decorticated a few inches above and below the wounded part, by means of a garden-pot previoufly broken longitudinally, and bound together round the branch, that roots will fhoot from the upper lip of the wound; and in a little time the branch may be fafely cut off below the garden-pot, and planted with fuccefs.

When a few inches of the end of a branch are cut off in the fpring, as is common in pruning wall-trees, new buds are produced near the extremity, which remains; or thofe, which did exift, grow with greater vigour; as they obtain fome of that nourifhment, which fhould have fupported the buds, which were cut off. The fame occurs in refpect to the fuckers or root-fcions of thofe trees, which produce them, as of elm-trees, and of fome apple-trees; if many of the branches be cut away, the fuckers or root-fcions become more numerous, or more vigorous.

This explains the ufe of a practice among many farmers of eating down a forward crop of wheat in the fpring with fheep. In this cafe the central or upright ftem of the wheat is decapitated, and many lateral ones, or root-fcions, as above defcribed, become generated, or grow with greater vigour; acquiring additional nourifhment from the joint, which was to have been expended in the growth of the central ftem; and which appears fo diftinctly in the preceding figure of a tranfplanted wheat-plant, which neverthelefs in crops, which are not too forward, may be very injurious, as fpoken of in Sect. XVI. 2. 3.

Thus the figure above alluded to explains four important circumftances in the cultivation of grains, that of earthing up the rows in

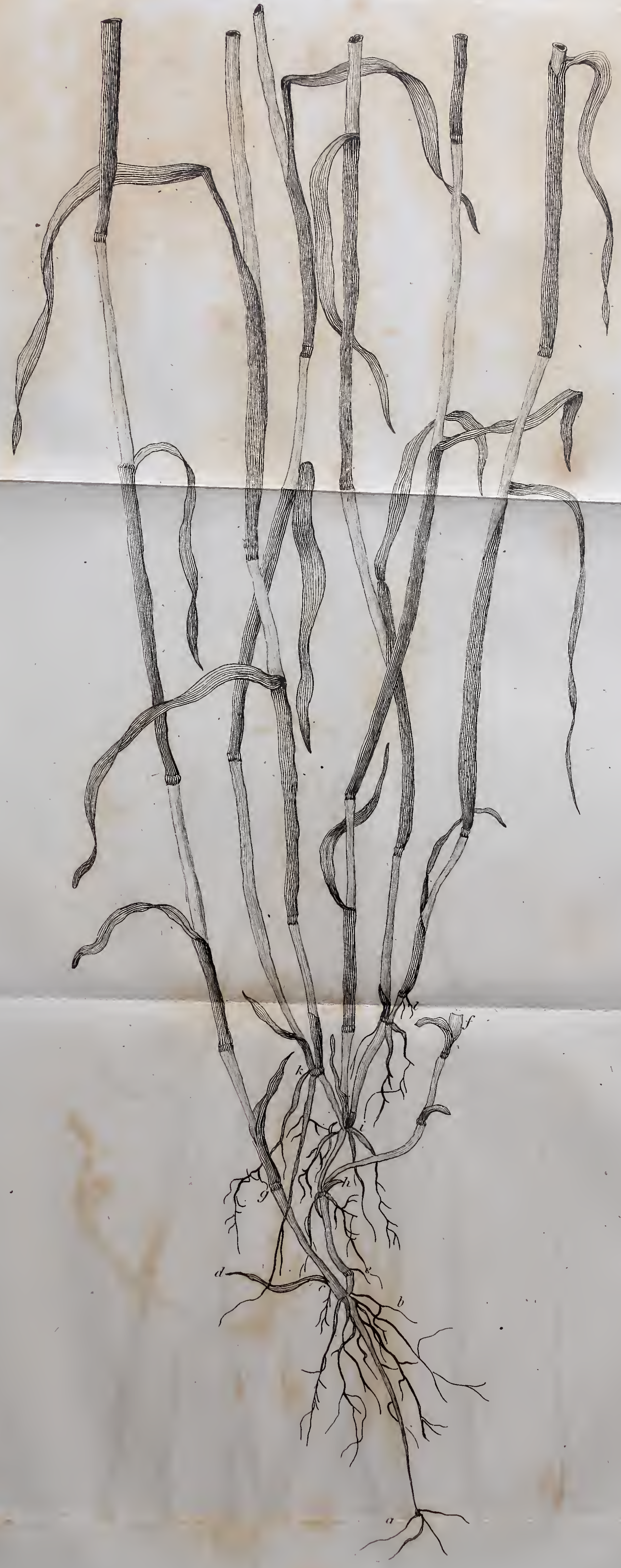
PLATE IV.

PLATE IV.

Reprefents a tranfplanted root of wheat defcribed in Sect. IX. 3. 7. *a* the feminal root, *b* the coronal root, *a b* the elongated caudex, *c g* the firft ftem, *c d* the firft leaf, *e f* a fecondary ftem. All thefe exifted before tranfplantation. The fecondary ftem was then cut off at *f*, and the plant was buried in the foil as deep as the letter *f*, where it was cut off. Afterwards the ftem, which was lopped, had put forth a new caudex or root-fcion at *h*; which had produced three new ftems at *i*; and other new ones, as it approached nearer the furface, at *k* and *l*. As thefe leaves advanced into the air, the latter new ftems were produced by the caudexes of them.

Plate IV.

Sect. IX. 3. 7.



ſpring by Mr. Tull's horſe-hoe; that of eating down the firſt ſtems of forward crops by ſheep; that of tranſplanting the roots deeper in the ſoil; and that of ſowing the ſeed an inch or two beneath the ſurface. For an account of the drill huſbandry now practiſed by Mr. Coke of Holkham in Norfolk, ſee Sect. XVI. 2. 2.

SECT.

SECT. X.

MANURES, OR THE FOOD OF PLANTS.

I. 1. *The* CHYLE *of all animals is ſimilar. It conſiſts of water, ſugar, mucilage, oil, with carbon, phoſphorus, and calcareous earth. The* SAP-JUICE *of vegetables conſiſts of water, ſugar, mucilage, with carbon, phoſphorus, and calcareous earth.* 2. *Food of young animals, of adult animals. Power of digeſtion. Production of ſugar by digeſtion.* 3. *Food of young vegetables. Production of ſugar by germination.* 4. *Food of adult plants from the ſpontaneous decompoſition of vegetable and animal bodies, or from water and air alone. They poſſeſs low heat and cold blood like winter-ſleeping animals. Diſtinction between animals and vegetables.* II. 1. AIR. *Oxygen in air, in water, united with heat, and light.* 2. *Forms all acids.* 3. *Metallic oxydes.* 4. *The baſes of all acids are inſoluble in water.* 5. *Carbonic acid gas from fermentation. In its fluid ſtate.* 6. *Aqueous acid.* 7. *Oxygen in vegetable perſpiration.* 8. *Plants ſprinkled with oxygenated water. Oxygen gas applied near their roots.* 9 *Azote or nitrogen is found in vegetables. Produces nitre and ammoniac* III. 1. WATER. *Its large quantity in plants.* 2. *Uſe of their great perſpiration.* 3. *Water becomes decompoſed in plants, and is hyper-oxygenated.* 4. *Gives lubricity, fluidity, and ſolution.* 5. *Irrigation of the ſoil brings other manures.* 6. *Penetrability of the ſoil from irrigation. Sow and reap early in wet ſoils.* 7. *Haſty ſhowers are injurious. Hills ſhould be ploughed horizontally. Uſe of ridges and furrows Surface of air greater.* 8. *Evaporation produces cold. Uſes of coping-ſtones on fruit-walls.* 9. *Production of foliage requires more moiſture than that of ſeeds. Froſt in Scotland ripens the corn.* 10. *Lime and dung-hills attract water. Steam uſed in hot-houſes. Much water in the atmoſphere.* IV. 1. CARBON *is an univerſal material in the atmoſphere.* 2. *In limeſtone.* 3. *In black earth, moraſſes, loam. Carbon combines with putrid exhalations.* 4. *United with oxygen is ſoluble in water. Lime combines with water. Emits heat. Is broken into powder by ſteam. Should be ſlaked before it is uſed in agriculture. Better ſlaked with hot water.*

Attracts

Attracts the carbonic acid, and in consequence the water, of the atmosphere. 5. *Carbonic acid subsides on the earth in the air.* 6. *United with calcareous earth is soluble in water, and absorbed by vegetables.* 7. *An experiment in which carbon and lime form an hepar, and thus become soluble in water.* 8. *Vegetable roots absorb carbonic acid from limestone in its fluid, not its gasseous state.* 9. *Carbon exists in sugar and mucilage, which are absorbed undecompounded.* V. PHOSPHORUS *is a simple substance. Appears in rotten wood. In putrescent flesh and fish.* 2. *Exists in all vegetable and animal matter, as seen in Homberg's pyrophorus, and in Kunkel's phosphorus.* 3. *And in all calcareous earth, as in oyster-shells, limestone, gypsum, fluor.* 4. *Hence the use of calcareous earth in agriculture.* 5. *Shells become limestone by attracting carbonic acid from the air. Mountains of calcareous phosphorus. Limestone should be burnt in close vessels.* 6. *The hardness of bones owing to phosphoric acid, and perhaps of ligneous fibres.* VI. 1. LIME *with carbon may make an hepar carbonis soluble in water.* 2. *Unites with carbonic acid, and renders it soluble in its fluid not its gasseous state. Water from springs is preferable to that from rivers for flooding lands.* 3. *Lime unites with phosphorus, and renders it soluble in water. Unites also with phosphoric acid. Whence crab-fish renew their shells, and snails repair and enlarge theirs.* 4. *Lime unites with oil and mucilage, and may thence become nutritious. It decomposes soap, and constitutes a part of animals and vegetables.* 5. *Lime destroys the cohesion of dead vegetables. Of recent ones by combustion. Attracts moisture from the air and earth. Makes clay less adhesive. Unites with acids of vitriol and of nitre. Kills insects.* 6. *One limestone twenty miles long and ten broad. Lime not of use on wet land, nor always on all calcareous soils.* 7. *Lime both forwards the ripening and meliorates and increases wheat and grass by supplying nutriment.* 8. *Gypsum, fluor, bone ashes. Breedon lime is half magnesia.* VII. 1. CLAY *is too adhesive. Becomes more solid by frost.* 2. *Effervesces in the air. Acquires oxygen. So iron, manganese, zinc. Raddle used as manure.* 3. *Granite acquires oxygen. Granites and dry clay have a smell when breathed on. Marl crumbles in the air. Burnt clay acquires oxygen and burnt lead.* 4. *Burnt clay promotes the generation of nitre. Use of paring and burning.* 5. *Burnt clay decomposes marine salt. Use of sea-salt in manure.* 6. *Would phosphat of lime combine with clay, or bone-ashes?* 7. *Cohesion of clay overcome by air. By roots of strong plants. By carbonic acid from leaves in the shade. By dunghill water. By lime.* 8. *Aluminous clays how to correct. By wood-ashes, soap-suds, lime, magnesia.* VIII. 1. SPON-

TANEOUS MANURES. *Saccharine fermentation is a chemical procefs. Exifts beneath the foil.* 2. *Vinous fermentation. Carbon and oxygen in a fluid ftate. Heat of bark-beds. Hay-ftacks take fire.* 3. *Putrefaction decompofes water.* 4. *Produces nitre, whofe loofe oxygen promotes vegetation.* 5. *Sow foon after the plough.* IX. CHEMICAL MANURES. 1. *Sugar and mucilage abforbed undecompofed.* 2. *Heat deftroys life in feeds, fruits, roots. Potatoes dried on a malt-kiln. Cooked in fteam hotter than boiling water. Papin's digefter.* 4. *Trituration of wood, ftraw, hay, for food in times of fcarcity; of bones, chalk, bricks, ochres, calamy for manures.* X. INSECT-MANURE. *Cultivated countries increafe in fertility. Some have decreafed. Calcareous ftrata from fhells. Thofe above them from vegetables and animals. The former can live on air and water, not the latter.* 2. *Crops ploughed in for manure.* 3. *Infects increafe manure. Water from dunghills.* 4. *Fifh.* XI. PRESERVATION OF MANURES. *Rains wafh manure into the fea. Snow floods lefs injurious. Hills fhould be ploughed horizontally.* 2. *Common fhores.* 3. *Burial grounds.* 4. *Wood-fuel.* 5. *Fermentation requires air, water, heat. Manure fhould be turned over and mixed with lime.* 6. *Pig-troughs, foap-fuds.* 7. *Weeds, leaves, water-plants.* 8. *Peat.* XII. APPLICATION OF MANURES. 1. *In powder for top-dreffing. In ftraw for clay-fields.* 2. *In fields when the corn is fowed. On grafs-lands in the fpring, not in the autumn.* 3. *Cover dung-heaps with foil. Gather cow-dung from the grafs.* 4. *What manures are moft nutritive. Flefh, horn, woollen rags, meal, fugar, oil.*

I. 1. The various fubftances, which conftitute animal bodies, or which are found in the cavities of them, are compofed from fimpler elements by the proceffes of digeftion, and fanguification, and fecretion; for it is well known, that even milk, which fo much refembles the chyle of animals, is not abforbed by the lacteals without its being previoufly coagulated, and again diffolved in the ftomach by the power of digeftion.

Hence it happens, that the chyle of all animals, and from every kind of food which they take into their ftomachs, is very fimilar; and like milk confifts of water, fugar, mucilage, and oil; the laft of which

which not being ſoluble in water, but only miſcible with it, gives it its opaque white colour.

But though the chyle from different kinds of aliment is ſo ſimilar, and all the various conſtituent parts of animal bodies are ultimately produced from the chyle by ſanguification and ſecretion, yet it happens, that ſome kinds of aliment poſſeſs a greater quantity of theſe particles, which make chyle, than other kinds of aliment. Such materials for inſtance as already contain much ſugar, mucilage, and oil, as the fleſh of dead animals, or the fruits and ſeeds of vegetables.

Beſides the water, ſugar, mucilage, and oil, which exiſt in chyle, there may be other materials, which are inviſible from their perfect ſolution in water, either alone or when converted into acids by the addition of oxygen ; as carbon, phoſphorus, calcareous earth, marine and ammoniacal ſalts ; though it is more probable, that the two laſt are formed and ſecreted by animal proceſſes, as well as ſelected by their abſorbent roots, as they are more compounded bodies than the former.

Similar to this chyle of animals the ſap-juice, which is abſorbed from the earth by the roots of plants, conſtitutes their nouriſhment, and conſiſts of water, ſugar, and mucilage, with other tranſparent ſolutions, as of carbon, phoſphorus, and calcareous earth. And though it has been proved by the experiments of ſome philoſophers, that vegetables can extract or compoſe all theſe ſubſtances from air and water alone ; yet ſome materials contribute more to the production of this vegetable chyle or ſap-juice than others, ſuch as the recrements of dead vegetable and animal ſubſtances.

2. If any one ſhould aſk, what is the food of animals ? I ſhould anſwer, that in the moſt early ſtate of animal life the embryon lives on a mucilaginous fluid, with which it is ſurrounded, whether in the egg or womb: that in its infant ſtate the young animal is ſuſtained by milk, which its ſtomach converts into chyle.

In their adult ſtate animals are ſuſtained by other vegetable or animal ſubſtances taken into their ſtomachs, which are there converted into chyle partly by a chemical, and partly by an animal proceſs; as by a mixture of gaſtric juice with water and heat, ſome of theſe recrements of organic nature are decompoſed, either into their ſimpler component parts, or ſometimes even into their elements; while other parts of them are only rendered ſoluble or miſcible with water; and are then drank up by the abſorbents of the ſtomach and inteſtines.

In this proceſs of digeſtion much ſugar is produced, which is probably immediately ſelected and drank up by the numerous mouths of the lacteals, or lymphatics; to which it is preſented by the vermicular or periſtaltic motions of the ſtomach and inteſtines. And as this ready ſelection and abſorption of the ſugar, as ſoon as it is formed, prevents it from paſſing into the vinous or acetous fermentation; it is probable that from the want of ſuch a means of ſeparating ſaccharine matter, as ſoon as it is formed, chemiſtry has not yet been able to produce ſugar from its elements without the aſſiſtance of animal digeſtion, or vegetable germination; as further ſpoken of in No. 8. 1. of this ſection.

In this proceſs of digeſtion, I believe, a great part of the water, ſugar, mucilage, and oil, which exiſt in vegetable and animal recrements, are not decompoſed into their elements, but abſorbed by being ſoluble or miſcible with water; the carbon, and the phoſphorus, and the hydrogen, are alſo I ſuppoſe diſſolved in the other fluids by means of oxygen, and form a part of the chyle, without their being converted into gaſſes; for when this happens to any exceſs in reſpect to carbon, it eſcapes from the ſtomach in eructations; and the ſame occurs to the inflammable air or hydrogen, if a part of the water becomes decompoſed in the inteſtines; which, if it be not abſorbed by its ſolution in other fluids, but acquires a gaſſeous ſtate, is liable to eſcape below; though both theſe gaſſes ſeem occaſionally

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to revert to a fluid ſtate from their aerial one in the ſtomach or inteſtines, and to be then abſorbable by the lacteals or lymphatics.

3. What then is the food of vegetables? the embryon plant in the ſeed or fruit is ſurrounded with ſaccharine, mucilaginous, and oily materials, like the animal fetus in the egg or uterus, which it abſorbs, and converts into nutriment; while the embryon buds of deciduous trees, which is another infantine ſtate of vegetables, are ſupplied with a ſaccharine and mucilaginous juice prepared for them at the time of their production, and depoſited in the roots or ſap-wood of their parent-trees; as in the vine, maple, and birch; which ſaccharine matter is ſoluble and miſcible with the water of the ſurrounding earth in the ſubſequent ſpring, and is forcibly abſorbed by their root-veſſels, and expands their naſcent foliage.

In their infantine ſtate therefore there is a wonderful analogy between plants and animals; and it is particularly curious to obſerve in the proceſs of converting barley into malt by the germination of the ſeed, that the meal of the barley is in part converted into ſugar by the digeſtion of the young plant exactly as in the animal ſtomach. The wonderful effect of vegetable digeſtion in producing ſugar may be deduced from the great product of the ſugar-cane, and of the maple-tree in America, mentioned in Sect. III. 2. 3. and the wonderful effect of animal digeſtion in producing ſugar appears in patients, who labour under diabetes. A man in the Infirmary of Stafford, who drank daily an immoderate quantity of beer, and who eat above twice the quantity of food that thoſe in health conſume, voided ſixteen or eighteen pounds of water daily, from each pound of which above an ounce of coarſe ſugar was extracted by evaporation. Zoonomia, Vol. I. Sect. XXIX. 4. 9.

4. We now come to conſider the food of adult plants; and in this conſiſts the great and eſſential difference between the nutritive proceſſes of animals and vegetables. The former are poſſeſſed of a ſtomach, by which they can in a few hours decompoſe the tender parts

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of vegetable and animal ſubſtances by a chemical proceſs within themſelves, conducted in the heat of ninety-eight degrees, with a due quantity of water, and a perpetual agitation of the ingredients; which both mixes them, and applies them to the mouths of the abſorbent veſſels, which ſurround them. Whereas a vegetable being having no ſtomach is neceſſitated to wait for the ſpontaneous decompoſition of animal or vegetable recrements; which is indeed continually going on in thoſe ſoils, and climates, and in thoſe ſeaſons of the year, which are moſt friendly to vegetation; but is in other ſituations, and in other ſeaſons, a ſlow proceſs in a degree of heat often as low as forty of Farenheit, (in which the reindeer moſs, moſchus rangiferinus, vegetates beneath the ſnow in Siberia,) and often without an adapted quantity of water to give a due fluidity, or any mechanical locomotion to preſent them to the abſorbent mouths of their roots; or in ſtill worſe ſituations adult vegetables are neceſſitated ſtill more ſlowly to acquire or produce their nutritive juices from the ſimpler elements of air and water, with perhaps the ſolutions of carbonic acid and calcareous earth, and perhaps of ſome other matters, with which one or more of them abound.

But M. Haſſenfratz found, that the vegetation of thoſe plants was imperfect, which had not been ſuffered to grow in contact with the earth; as they never arrived at ſuch maturity as to produce fruit; and were found on analyſis to contain a leſs portion of carbon, than other plants of the ſame kind. The experiments were tried on hyacinths, kidney-beans, and creſſes.

Hence the other great difference, which exiſts between theſe two extenſive kingdoms of nature, is, that the larger and warmer blooded animals certainly, and I ſuppoſe all the tribes of inſects, and of colder blooded creatures alſo, can not exiſt long on air and water alone, except in their ſtate of hibernal torpor. The neareſt approach to this is however ſeen in ſome fevers, where water alone has been taken for a week or two, and yet the patient has recovered; and there is a well atteſted attefted account of a numerous caravan, which having loft their rout, or their provifions, are affirmed to have lived fome weeks on gum arabic and water alone.

Vegetables on the contrary, as above mentioned, can exift, though in a feebler ftate, on water and air alone, with the carbonic acid, and perhaps other invifible folvends, which thofe elements unavoidably contain. This I fuppofe to be owing to the low degree of heat, which they produce internally, and to the flow circulation of their blood; from both which circumftances lefs nutriment is expended, as by animals which fleep in winter.

For the purpofe of fupplying adult vegetables with nourifhment, we fhould firft confider what kinds of matter are moft prevalent or moft neceffary in their compofition. Secondly, what of thefe fubftances they can abforb without previous decompofition. Laftly, how to expedite the decompofition of vegetable and animal fubftances on or in the foil, like the digeftive proceffes in the ftomachs of animals; we may thus become acquainted with the fources and the management of manures.

II. AIR.

1. Oxygen combined with heat conftitutes that part of the atmofphere, which is perpetually neceffary to animal and vegetable refpiration; and a greater part of that water, which forms a principal portion of their organization; a few words may be therefore premifed on thefe moft important difcoveries of modern chemiftry.

This vital air, called oxygen gas, conftitutes twenty-feven hundredth parts of the atmofphere; it is indifpenfably neceffary to the exiftence of life, and of combuftion, and forms the principal part of all acids; whence its name. The other feventy-three hundredth parts of the atmofphere confift of azote, which takes its name from its inutility to life in animal refpiration; it is alfo called nitrogen, becaufe it conftitutes the bafis of nitre.

Oxygen gas confifts of oxygen and heat; and when it unites with fuch bodies, as are capable of uniting with it, the heat is fet at liberty, as in refpiration and in combuftion; in both which proceffes an acid is produced by the combination of oxygen with fome inflammable bafe. Hence vital air confifts of oxygen diffolved in the fluid matter of heat; but there is alfo another fluid, which feems to be combined with this folution of oxygen in heat, and that is light. For when oxygen becomes combined with charcoal, or with fulphur, or with phofphorus, both heat or light are fet at liberty from thefe new combinations of oxygen; which thus produce the carbonic, fulphuric, and phofphoric acids.

When thefe new combinations of oxygen are performed very flowly, the light is fometimes not vifible, as in the heating of a dunghill; in which procefs the oxygen in the cells or cavities of the hotbed unites flowly with the carbon and phofphorus of the decompofing vegetable and animal matters; but though much heat is given out, no light is feen. While on the contrary from rotten wood alone, or putrefcent fifh, when expofed to the atmofphere, much light is emitted, but not much fenfible heat, owing perhaps fimply to the combuftion of the phofphorus, which they contain.

2. The products of thefe combinations of oxygen with other bodies may all of them be termed acids; though in fome the heat or light fet at liberty converts thefe acid productions into gaffes, as oxygen and charcoal form carbonic acid gas; and in others it converts the new product into fteam, which is condenfible by cold, as the fulphuric acid from the combination of oxygen and fulphur; and the phofphoric acid from oxygen and phofphorus.

3. Other combinations of oxygen with heavier fubftances are produced in the atmofphere without the feparation of either fenfible heat, or vifible light; as the union of oxygen with metallic bodies, as with that of manganefe, with zinc, lead, iron, as in common ore of manganefe, in lapis calaminaris, white calciform lead-ore, and the

red ochre of iron; which have not obtained the name of acids, but are termed oxydes of thofe minerals.

4. Now it happens, that none of thefe bafes, which can combine with oxygen alone, are foluble in water, and therefore can not be imbibed by the abforbent veffels of vegetable roots, until they become acids; and are perhaps then all of them in greater or lefs quantities foluble in water; and are thence capable of being drank up by the abforbent veffels of vegetable roots, and conftitute a part of the food of plants.

5. When vegetable fubftances are decompofed by fermentation, there is a quick union of oxygen and carbon; and this carbonic acid gas, called formerly fixed air, rifes up in vapour, and flies away. But where this procefs goes on more flowly, as in a dung-hill lately turned over, or in black garden mould lately turned over, and thus expofed to the air; much of which remains in the cells or cavities of the hotbed, or border; this carbonic acid is flowly produced, and is abforbed by vegetable roots, I fuppofe in its fluid ftate, or diffolved in water, before it acquires fo much heat as to rife in the atmofphere in the form of gas.

This carbonic gas in its fluid ftate, or diffolved in water, not in its aerial or gaffeous ftate, is the principal food of plants; as appears, becaufe their folid fibres confift principally of carbon, and their fluids of water.

6. Next to carbonic acid the aqueous acid, if it may be fo called, or water, feems to afford the principal food of vegetables; as water confifts of oxygen and hydrogen, it is properly an acid, like all other combinations of oxygen; and when abforbed by vegetable roots becomes in part decompofed in the circulation or fecretion of their juices; the oxygen difappears, or contributes to form the vegetable acids; and the hydrogen produces ammonia by its union with azote; which may contribute to vegetable nutriment by its mixture with oils, and thus producing foaps, which become diffufible in water; and alfo by

decompoſing inſoluble ſaline earths, as gypſum, or metallic ſalts, as vitriol of iron, and thus producing more ſoluble or innocuous ſalts. And which laſtly forms a part of the various vegetable productions of ſugar, honey, wax, reſin, and other ſecretions.

7. There is a curious evolution of oxygen attends the perſpiration of the leaves of plants, which is not known to attend that of animal lungs; and that is, that when vegetable leaves are expoſed to the ſun's light, they ſeem to give up oxygen gas; but in the dark they give up carbonic acid gas, like the breath of animals. It is probable that animal lungs might do the ſame, if they were expoſed to the light; as perhaps might be ſubjected to experiment in the gills of fiſh, or by breathing through a tube into water in the ſunſhine.

In reſpiration as well as in combuſtion ſome light may poſſibly be given out as well as ſome heat from the combination of oxygen with ſome phlogiſtic baſe, as carbon or phoſphorus; whence the production of carbonic and phoſphoric acids in both animal and vegetable reſpiration. In moſt animals this quantity of light is probably too ſmall to be perceived, if their bodies were tranſparent; but in the glow-worm of this country, and in the more luminous fire-flies of the tropical climates, I ſuſpect the light to be emitted from their lungs in the act of reſpiration, which is a ſlow combuſtion.

8. Beſides the uſe of oxygen in the reſpiration of vegetables, when applied to their leaves, as it is mixed in the atmoſphere; it is believed by many to contribute much to their growth and nouriſhment in its combined ſtate, when abſorbed by their roots; and that by the decompoſition of water in the vegetable ſyſtem, when the hydrogen unites with carbon and produces oil, the oxygen becomes ſuperfluous, and is in part exhaled, as further ſpoken of in Sect. XIII. 1. 2. Hence alſo ſome calciform ores, or metallic oxydes, as raddle, and calamine, and burnt clay, are ſuppoſed to be uſeful as manures, becauſe they contain much oxygen, as mentioned in No. 7. 1. of this Section.

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Mr. Humboldt aſſerts, that on putting creſſes, lepidium ſativum, into oxygenated muriatic acid gas mixed with water, they produced germs in ſix hours; while thoſe in common water were thirty-ſix hours before they produced germs. Jacquin at Vienna put many old ſeeds, which had been in vain tried if they would vegetate, into ſuch a ſolution of oxygenated muriatic acid, and found great numbers of them quickly to vegetate. Journal de Phyſique, 1798. See Sect. XIV. 2. 5.

In the experiments of ſir Francis Ford many plants, which were ſprinkled with water previouſly impregnated with oxygen gas, are ſaid to have grown more vigorouſly, and to have diſplayed more beautiful tints, than thoſe nouriſhed with common water. Other experiments are ſaid to have been made by inverting bottles filled with oxygen gas, and burying their open mouths beneath the ſoil near the roots of vegetables, which are ſaid to have grown more healthy and beautiful, as the oxygen became abſorbed, and was ſucceeded by air like the common atmoſphere. Philoſ. Magaz. 1798, p. 224. Further experiments are required on this ſubject, ſince the fluids of vegetables would in general appear to be hyperoxygenated from the oxygen emitted from the perſpiration of their leaves in the ſunſhine, and which is believed to ariſe from the decompoſition of water in their arteries or glands.

9. We now come to the other ingredient, which conſtitutes a much greater part of the atmoſphere than the oxygen, and this is the azote, or nitrogen; which alſo ſeems much to contribute to the food or ſuſtenance of vegetables; for though azote, or nitrogen, enters into animal bodies in much greater quantities perhaps than into vegetables, ſo as to conſtitute according to ſome chemical philoſophers the principal difference between theſe two great claſſes of organized nature; yet it enters alſo into the vegetable ſyſtem, and is given out by their putrefaction; and alſo when lime is applied to moiſt vegetables it diſengages from them both hydrogen and azote forming

volatile alkali, as aſſerted in the ingenious work of Lord Dundonald on the Connection of Agriculture with Chemiſtry.

The azote of the atmoſphere, when air is confined in the interſtices of the ſoil newly turned over by the plough or ſpade, contributes to the production of the nitrous acid by its union with the oxygen of the atmoſphere, with which it was before only diffuſed, or with the much greater ſource of oxygen from the decompoſing water of the ſoil. At the ſame time another part of the abundant azote combines with the hydrogen of the decompoſing water of the ſoil, and produces ammonia or volatile alkali; which contributes to the growth of vegetables many ways, as already deſcribed in No. 2. 6. of this Section.

III. WATER.

1. The neceſſity of much water in the progreſs of vegetation appears from the great quantity, which exiſts naturally in all parts of plants; inſomuch that many roots, as ſquill and rhubarb, are known to loſe about ſix parts out of ſeven of their original weight ſimply by drying them before the fire; which quantity of moiſture nevertheleſs does not exhale in the common heat of the atmoſphere during the life of the root; as is ſeen in the growth of ſquills in the ſhops of the druggiſts, and of onions on the floors of our ſtore-rooms.

2. A ſecond neceſſity of much water in the economy of vegetation may be deduced from the great perſpiration of plants, which appears from the experiments of Hales and others; who like Sanctorius have eſtimated the quantity of their perſpiration from their daily loſs of weight; which however is not an accurate concluſion either in reſpect to plants or animals, as they both abſorb moiſture from the atmoſphere, as well as perſpire it.

This great perſpiration of vegetables, like that from the ſkin and lungs of animals, does not appear to conſiſt of excrementitious matter, becauſe it has in general no putreſcent ſmell or taſte; but ſeems

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to be fecreted firft for the purpofe of keeping the external furface of the leaves from becoming dry, which would prevent the oxygen of the atmofphere from entering into the vegetable blood through them; fince according to the experiments of Dr. Prieftley on animal membranes the oxygen will only pafs through them, when they are moift. A fecond ufe of this great perfpiration is to keep the bark fupple by its moifture, and thus to prevent its being cracked by the motion of the branches in the wind. And though a great part of this perfpirable matter is probably abforbed, as on the fkins of animals; yet as it exifts on fo large a furface of leaves and twigs, much of it muft neceffarily evaporate on dry and windy days.

3. One of the great difcoveries of modern chemiftry is the decompofition of water, which is fhewn both by analyfis and fynthefis to confift of eighty-five hundredth parts of oxygen, and fifteen of hydrogen. Hence a third great ufe of water in the vegetable economy is probably owing to its ready decompofition by their organs of digeftion, fanguification, and fecretion. This is evinced firft by the great quantity of hydrogen, which exifts in the compofition of many of their inflammable parts. And fecondly, from the curious circumftance, which was firft difcovered by the ingenious Dr. Prieftley, that the water, which they perfpire, is hyperoxygenated; and in confequence always ready to part with its fuperabundance of oxygen, when expofed to the fun's light; from whence it may be concluded, that part of the hydrogen, which was previoufly an ingredient of this water, had been feparated from it, and ufed in the vegetable economy, as is further treated of in Section XIII. 1. 2.

Add to this, that from the decompofition of water, when confined in contact with air beneath the foil, the nitrous acid feems to be produced and ammonia, both which are believed ufeful to vegetation, as mentioned in No. 2. 6. of this Section.

4. Befides the peculiar ufes of a great quantity of water, as above defcribed, the more common ufes of it both to vegetable and animal

life,

life, along with the matter of heat, are to produce or preferve a due fupplenefs or lubricity of the folids, and a due degree of fluidity of the liquids, which they contain or circulate. And laftly, for the purpofe of diffolving or diffufing in it other folid or fluid fubftances, and thus rendering them capable of abforption, circulation, and fecretion.

5. The due irrigation of the foil is much attended to in drier and warmer countries, as in Italy, Egypt, and fome parts of China; where numerous canals, and aqueducts, have been dug through hills, and carried over vallies, for the purpofe of watering the foil; and even in this colder and moifter climate the practice of flooding land is coming daily into greater repute. For this occafional fuffufion of water over land not only fupplies fimple moifture for the purpofes above mentioned in the drier parts of the feafons, but brings along with it calcareous earth and azotic air from the neighbouring fprings, or other manures from the rivers. Calcareous earth may be detected in the water of all thofe fprings which pafs under or over ftrata of marle or limeftone, by dropping into them a folution of falt of tartar; or of fugar of lead in water, or of foap in fpirits of wine; and a portion of azotic gas was difcovered in Bath-water by Dr. Prieftley, and in Buxton-water by Dr. Pierfon. See Section XI. 3. 1. Dr. Home thinks he difcovered nitrat of lime in hard water, and found by his experiments that it promoted the growth of plants in a much greater degree than foft water.

6. Another demand for water in agriculture is to give a due penetrability to the foil, which otherwife in moft fituations becomes fo hard as to ftop the elongation of the tender roots of plants; but the cohefion of the foil may neverthelefs be too much diminifhed by great and perpetual moifture, fo as not to give fufficient firmnefs to the roots of trees. And befides this too much as well as too little water may be fupplied to the generality of vegetables, which grow upon the land; though there are aquatic and amphibious plants as well as

aquatic and amphibious animals, and which differ from each other as fiſh and ſeals from quadrupeds.

Where land abounds too much with moiſture, the art of making ſubterraneous or ſuperficial drains deſcribed in Sect. XI. 1. muſt be had recourſe to. But where theſe are not executed, in lands not very moiſt it is thought advantageous to ſow the crops early before the wet ſeaſon, ſince corn will bear much more moiſture after it has ſhot from the ſeed, than the ſeed will bear; as the ſeed is leſs tenacious of life, and in conſequence more liable to putrify. The crops ſhould likewiſe be ſown or planted thinner, and be reaped early in the ſeaſon, as the excluſion of the air by thick foliage, and the greater dampneſs of the autumn, are liable to generate mildew in moiſt ſituations. Perhaps it ſhould be added, that ſowing early, and the conſequent reaping early, has ſo many advantages in all ſeaſons on all lands, that it may in general be univerſally recommended; and that in wet lands it might be very advantageous to cultivate crops by tranſplantation in the vernal months, having previouſly ſowed the ſeed in drier or warmer ſituations. See Sect. XVI. 8. 1.

7. Another injury in this climate occaſioned by too great a quantity of water ariſes from haſty ſhowers; which waſh off much of the decompoſing animal and vegetable recrements, which are ſoluble or diffuſible in water, and carry them down the rivers into the ſea. From the ſides of hills this damage is accompliſhed by ſmall ſhowers, on which account all ſloping grounds when applied to agriculture ſhould be ploughed horizontally, as by the ridges and furrows thus produced the ſmaller ſhowers of rain will not paſs ſo haſtily off, as when they are ploughed vertically.

A queſtion here occurs, whether it be advantageous to plough level plains into ridges and furrows? the Chineſe are ſaid never to divide their fields into ridges and furrows, but to plant their grain on an even ſurface. Embaſſy to China by ſir G. Staunton, Vol. III. p. 197, 8vo. edit. Some think it an error to ſuppoſe, that any increaſe of

crop

crop can be thus obtained, as no more plants can riſe perpendicularly from the ground; but in the ripening of grain the ſurface of air to which the ears are expoſed is alſo to be conſidered ; which correſponds with the ſurface of the ground, and is increaſed by its being laid in hill and dale. But there is a ſerious objection to this mode of ploughing in moiſt ſituations without ſufficient declivity, as the corn in the furrows appears weak and backward owing to the rain lying on it too long ; and alſo to the beſt part of ſhallow ſoils being frequently taken from them to conſtruct the ridges. See Sect. XVI. 2. 2.

8. Add to this, that the evaporation of moiſture from the ſurface of the earth produces ſo much cold as to injure thoſe terreſtrial plants, which are too long covered with it. On this account thoſe parts of wall-trees, which are ſheltered from the deſcending dews by a coping ſtone on the wall, are not ſo liable to be injured by froſty nights on two accounts ; both as they are not made colder by the evaporation of the dew, and alſo have leſs water to be congealed in their veſſels, and by its expanſion to burſt them.

9. Laſtly, the foliage on buds of plants, which conſtitute one part of their progeny, requires more moiſture for its vigorous growth, than their flowers or organs of ſexual generation. Hence in warm countries the rice-grounds are flooded only till the ſeaſon of flowering commences, and are laid dry again for the purpoſe of maturating the ſeed ; and in our climate continued rains are liable not only to waſh off the farina from the burſting anthers, and thus prevent the impregnation of the piſtillum, but alſo to delay the ripening of the fruit or ſeeds from the want of a due evaporation of their perſpirable matter, as well as from the leſs ſolar light in cloudy ſeaſons ; whence in the north of Scotland the oats are ſaid ſeldom to ripen till the froſt commences with the dry ſeaſon, which accompanies it.

10. There are methods of procuring or preſerving the ſalutary moiſture of the ſoil beſides thoſe of canals and aqueducts, which ſhould

ſhould be here mentioned. Theſe are by uſing as manures ſuch ſubſtances as perpetually attract moiſture from the lower part of the ſoil, or from the atmoſphere; as quick-lime, and vegetable and animal recrements in the act of putrefaction.

In hot-houſes ſome have already employed ſteam as a means both of giving warmth and moiſture to the included plants, or to the ſoil in which they grow; and a great variety of forcing pumps have been conſtructed for the purpoſe of moiſtening the foliage of wall-trees; but there is a hope from the preſent great progreſs of chemical reſearch, that a means may ſometime be diſovered of precipitating the water of the atmoſphere, which the ingenious biſhop Watſon thinks always exiſts in it in ſuch quantity as, if it was ſuddenly precipitated, might again deluge the world.

IV. CARBON.

1. When animal and vegetable bodies are burnt without the acceſs of air, that is, when their volatile parts are ſublimed; there remains a great quantity of charcoal, a much greater in vegetable bodies than in animal ones; this is termed carbon by the French ſchool, when it is quite pure; and is now known to be one of the moſt univerſal materials of nature. And as vegetable bodies contain ſo much of it in their compoſition, they may be ſuppoſed to abſorb it intire, where they grow vigorouſly; eſpecially as it is a ſimple material; but they may poſſibly form it alſo occaſionally from water and air within their own veſſels, when they are ſecluded from acceſs to it externally.

The whole atmoſphere contains always a quantity of it in the form of carbonic acid, or fixed air; as is known by the ſcum, which preſently becomes viſible on lime-water, when expoſed to the air; and which conſiſts of a reunion of the lime with carbonic acid; which may therefore be ſaid to encompaſs the earth.

The ſimplicity of carbon, as an elementary ſubſtance, was diſputed by Dr. Auſtin, who believed he had decompounded it. But Mr. Henry, by accurately repeating his experiments, has ſhewn the fallacy or inconcluſiveneſs of them. Philoſ. Tranſact. 1797.

2. Another great reſervoir of carbon exiſts in limeſtone in the form of carbonic acid; which when a ſtronger acid is poured on the calcareous earth becomes a gas, acquiring its neceſſary addition of heat from that, which is given out in the combination of the ſtronger acid with the lime. It alſo acquires its neceſſary heat, when limeſtone is burnt, from the conſuming fuel, riſes in the form of gas, and is diſſipated in the air; and probably ſoon ſettles on the earth, as it cools, as it is ten times heavier than the common atmoſphere.

3. But the great ſource of carbon exiſts in the black earth, which has lately been left by the decompoſition of vegetable and animal bodies; and is then in a ſtate fit to combine with azote or nitrogen, and with oxygen, when expoſed to thoſe two gaſſes, as they exiſt in the atmoſphere; and is thus adapted either to promote the generation of nitrous acid, or to form carbonic acid, and thus to aſſiſt vegetation.

Moraſſes conſiſt principally of the carbonic recrements of vegetable matters, which are gradually decompoſed in great length of time into clay, with argillaceous ſand, ſuch as is found over coal-beds, and ſome calcareous earth, as in marl; and laſtly, with ſome iron, and foſſile coal. Theſe by elutriation are ſeparated from each other, and form the ſtrata of coal countries. In other places they remain intermixed, as they were probably produced from the decompoſition of vegetables and terreſtrial animals; and form what in books of practical agriculture is called a *loamy* ſoil, conſiſting of carbonic matter, ſand, and clay, with a portion of iron.

It has always been obſerved, that this black garden mould, or earth produced from the recrements of vegetables, is capable of abſorbing a much greater quantity of putrid effluvia than either air or water, and

6 probably

probably of combining with its ammonia, and producing a kind of hepar carbonis, and thus facilitating vegetation. The practice of burying dead bodies fo few feet below the furface is a proof of this; as the putrid exhalations from the carcafs are retained, and do not penetrate to the furface. On the fame account the air over new ploughed fields has long been efteemed falutary to invalids, or convalefcents, as it probably purifies the fupernatent atmofphere. But it was not till lately known that carbon, or charcoal, abforbs with fuch great avidity all putrid exhalations; if it has been recently burnt, and has not been already faturated with them, infomuch that putrid flefh is faid to be much fweetened by being covered a few inches with the powder of charcoal; or even by being buried for a time in black garden mould; as putrid exhalations confift chiefly of ammonia, hydrogen, and carbonic acid, and are the immediate products of the diffolution of animal or vegetable bodies, they are believed much to contribute to vegetation; as whatever materials have conftituted an organic body, may again after a certain degree of diffolution form a part of another organic body. The hydrogen and azote produce ammonia, which combining with carbon may form an hepar carbonis, and by thus rendering carbon foluble in water may much contribute to the growth of vegetables.

It has been faid, that fome moraffes have prevented the animal bodies, which have been buried in them, from putrefaction; which may in part have been owing to the great attraction of the carbon of the morafs to putrid effluvia, and in part perhaps to the vitriolic acid, which fome moraffes are faid to contain.

4. Here occurs an important queftion, by what other means is this folid carbon rendered fluid, fo as to be capable of entering the fine mouths of vegetable abforbents? The carbon, which exifts in the atmofphere, and in limeftone, is united with oxygen, and thence becomes foluble or diffufible in water; and may thus be abforbed by the living action of vegetable veffels; or may be again combined by

 chemical

chemical attraction with the lime, which has been deprived of it by calcination.

When mild calcareous earth, as limeftone, chalk, marble, has been deprived of its water and of its carbonic acid by calcination, it becomes lime. Afterwards when it is cold, if water be fprinkled on it, a confiderable heat is inftantly perceived; which is preffed out by the combination of a part of the water with the lime; as all bodies, when they change from a fluid ftate to a folid one, give out the heat, which before kept them fluid. At the fame time another part of the water, which was added, is raifed into fteam by the great heat given out as above mentioned; and the expanfion of this fteam breaks the lime into fine powder, which otherwife retains the form of the lumps of limeftone before calcination. But if too great a quantity of cold water be fuddenly added, no fteam is raifed; and the lump of lime retains its form; whence it happens, that fome kinds of lime fall into finer powder, and are faid to make better mortar, if flaked with boiling water than with cold.

On this account the lime, which is defigned to be fpread on land, fhould previoufly be laid on a heap, and either fuffered to become moift by the water of the atmofphere, or flaked by a proper quantity of water; otherwife if it be fpread on wet ground, or when fo fpread is expofed to much rain, the heat generated will be diffipated without breaking the lumps of lime into powder; which will then gradually harden again into limeftone, difappoint the expectation of the agricultor, and afflict him with the lofs of much labour and expence.

When the powder of flaked lime mixed with fand and water is fpread on a wall, that part of the water which is not neceffary for its imperfect cryftallization, evaporates into the air; and the lime then gradually attracts the carbonic acid, which is diffufed in the atmofphere; but as I fuppofe this carbonic acid is diffolved in the water, which is alfo diffufed in the atmofphere; the lime is perpetually moiftened

moiftened by this new acquifition of water from the air; as that, which before adhered to it, and had parted with its carbonic acid, evaporates. On which account new built walls are months, and even years, in drying, as they continue to attract water along with the carbonic acid from the air, which ftands upon them in drops, till the lime regains its original quantity of carbonic acid, and again hardens into ftone, or forms a fpar by its more perfect or lefs difturbed cryftallization.

5. The earth I fuppofe acquires carbon, both in a manner fimilar to the above by its attracting either the carbonic acid, or the water in which it is diffufed, from the atmofphere; and alfo by the fpecific gravity of carbonic acid gas being ten times greater than that of common air; whence there muft be conftantly a great fediment of it on the furface of the earth; which in its ftate of folution in oxygen and water may be readily drank up by the roots of vegetables.

6. Another means by which vegetables acquire carbon in great quantity may be from limeftone diffolved in water; which though a flow procefs occurs in innumerable fprings of water, which pafs through the calcareous or marly ftrata of the earth; as thofe of Matlock and Briftol in paffing through limeftone; and thofe about Derby in paffing through marl; and is brought to the roots of vegetables by the fhowers, which fall on foils, where marl, chalk, limeftone, marble, alabafter, fluor, exift; which includes almoft the whole of this ifland. By this folution of mild calcareous earth in water not only the carbon in the form of carbonic acid not yet made into gas, but the lime alfo, with which it is united, becomes abforbed into the vegetable fyftem, and thus contributes to the nutriment of plants both as fo much calcareous earth, and as fo much carbon.

7. Another mode by which vegetables acquire carbon, may be by the union of this fimple fubftance, with which all garden-mould abounds, with pure calcareous earth into a kind of hepar, analogous to the hepar of fulphur made with lime, which abounds in fome mineral

neral waters. And this I ſuppoſe to be the great uſe of lime in agriculture.

For the purpoſe of aſcertaining the probability of this mode of ſolution of carbon I made the following experiment. About two ounces of lime in powder were mixed with about as much charcoal in powder, put into a crucible, and covered with an inch or two of ſiliceous ſand. The crucible was kept red hot for an hour or longer, and then ſuffered to cool. On the next day water was poured on the lime and charcoal, which then ſtood a day or two in an open cup, and acquired a calcareous ſcum on its ſurface. And though it had not much taſte, except of the cauſticity of the lime, yet on dropping one drop of marine acid into a tea-ſpoonful of the clear ſolution a ſtrong ſmell like that of hepar ſulphuris was perceived, or like that of Harrogate water; which evinced, that the carbon was thus rendered ſoluble in water.

Perhaps the ſulphureous ſmell of Harrogate and Kedleſton waters, and other ſimilar ſprings, may be owing to the union of the alkali of decompoſing marine ſalt with the carbon of the earth, they run through? and this kind of water might thus poſſibly be uſed as a profitable manure?

8. Another mode by which vegetable roots acquire carbon, I ſuſpect to be by their diſuniting carbonic acid from limeſtone in its fluid not its gaſſeous ſtate; which the limeſtone again attracts from the atmoſphere and conſolidates, or from other matters included in the ſoil. Firſt, becauſe lime is believed by ſome agricultors, who much employ it, to do more ſervice in the ſecond year than in the firſt; that is in its mild ſtate, when it abounds with carbonic acid, than in its cauſtic ſtate, when it is deprived of it.

Secondly, that the uſe of burning lime ſeems hence to be ſimply to reduce it to an impalpable powder, almoſt approaching to fluidity; which muſt facilitate the application of the innumerable extremities of vegetable fibres to this uncalculable increaſe of its ſurface; which

may

may thence acquire by their abſorbent power the carbonic acid from theſe minute particles of lime, as faſt as they can recover it by chemical attraction from the air, or water, or from other inanimate ſubſtances in their vicinity.

Thirdly, the hyper-oxygenation of the perſpirable matter of plants, which thence gives up oxygen gas in the ſunſhine, would induce us to believe, that a great part of the carbon, which furniſhes ſo principal a part of vegetable nutriment, was received by their roots in the form of carbonic acid; and that it becomes in part decompoſed in their circulation, giving up its oxygen; which thus abounds in the ſecreted fluids of vegetables from this ſource, as well as from decompoſed water.

9. Another way by which carbon is received into the vegetable ſyſtem is by its exiſtence in ſugar and in mucilage; both which are taken up undecompounded, as appears by their preſence in the vernal ſap-juice, which is obtained from the maple and the birch; which like the chyle of animals, is abſorbed in its undecompounded ſtate.

V. PHOSPHORUS.

1. Another material which exiſts, I believe, univerſally in vegetables, and has not yet been ſufficiently attended to, is phoſphorus. This like the carbon, nitrogen, hydrogen, and ſulphur, is probably a ſimple ſubſtance; as our preſent chemiſtry has not yet certainly analyſed any of them; and therefore I ſuppoſe it is taken up intire by the abſorbent veſſels of vegetables, when it can be met with in a ſtate of ſolution; though it may alſo be occaſionally formed and ſecreted by them; and may hence be regiſtered among the articles of their food or ſuſtenance.

When wood is decompoſed by putrefaction in a certain degree of warmth and moiſture, it is often ſeen to emit much light in dark evenings, when recently broken and expoſed to the oxygen of the atmoſphere,

atmoſphere, ſo as to alarm benighted paſſengers; which is undoubtedly owing to the phoſphorus, which it contains, and which is at this time converted into phoſphoric acid. Such a light frequently is ſeen on putreſcent veal, when kept in a certain degree of warmth and moiſture; and on the ſea-weed placed on the oyſters packed in barrels, and ſent into the country; and in the ſtreets of Edinburgh, where the heads of the fiſh called whitings or haddies are frequently thrown out by the people, I have on a dark night eaſily ſeen the hour by holding one of them to my watch.

2. The exiſtence of phoſphorus in vegetables was detected by Margraaf; who found, that many vegetable matters, particularly farinaceous grains, contain enough of the phoſphoric acid to produce phoſphorus, when they are expoſed to great heat in cloſe veſſels. Macquer's Chemical Dictionary tranſlated by Mr. Keir, Vol. II. p. 535, Art. Phoſphorus. Phoſphorus has been detected in gum arabic, ſugar, honey, flour, and in every kind of vegetable or animal ſubſtance by the proceſs of making the phoſphorus of Homberg. And the exiſtence of phoſphorus in greater quantity in all the parts and recrements of animals, as in their fleſh, dung, urine, and bone-aſhes, and moſt copiouſly in the two latter, is evinced in the fabrication of Kunkel's phoſphorus. Whence its univerſal exiſtence is diſcovered in theſe two great kingdoms of nature. See the above Dict. Art. Pyrophorus.

The moſt eaſy proceſs for producing Homberg's phoſphorus conſiſts in mixing three parts of alum with one of ſugar, which are to be expoſed to a great heat in a covered crucible, till a bluiſh flame has appeared for ſome time. It muſt then be ſuffered to cool a little, and be put into a dry hot bottle, and cloſely ſtopped from the air. A drachm of this powder will afterwards, when poured from the bottle into the open air on paper, quickly kindle, become red like burning coals, and burn the paper, which it lies upon.

Hence we may conclude, that vegetable bodies, as well as animal ones,

ones, contain acid of phoſphorus; and that in this experiment the acid of the alum takes the fixed alkaline ſalt from the vegetable aſhes, and the calcareous earth, if ſuch there be, and that the carbon unites with the oxygen of the phoſphoric acid; and the vegetable phoſphorus is left mingled with the earth of alum; exactly in the ſame manner as the animal phoſphorus is obtained from the aſhes of bones, or the ſalt of urine, by calcining them in cloſe veſſels with charcoal.

3. An important queſtion now occurs; if this ſimple material of phoſphorus be not generally made in the veſſels of vegetables, whence do they acquire it? They may probably obtain it in conſiderable quantity from the recrements of decaying vegetable and animal bodies; as it appears in rotten wood, and in putrefying fiſh, and exiſts in ſuch large quantities in bone-aſhes, and in the ſalt of urine. But I ſuppoſe there is another great ſource of phoſphorus, I mean in calcareous earth, which alſo has been of animal origin in the early ages of the world.

If an oyſter-ſhell be calcined for about half an hour in a common fire, and is then kept from the air in a cold place; when it is afterwards expoſed for a while to the ſunſhine, and brought into a dark room, it will appear luminous like the calcined Bolognian ſtone; which is owing to the phoſphoric acid thus deprived of its oxygen by the carbon of the fire-coals, and intermingled with the pure calcareous earth or lime of the ſhell; and which again combining with the oxygen of the air, both light and heat are emitted in the reproduction of phoſphoric acid. See Wilſon on Phoſphori, Dodſley, London, 1795.

The Bolognian ſtone is a ſelenite or gypſum, which conſiſts of vitriolic acid and calcareous earth, and I ſuppoſe of acid of phoſphorus; ſince on mixing the powder of this ſtone with gum arabic, and calcining it ſome time, a kind of phoſphorus is produced ſimilar to the above, owing I ſuppoſe to the carbon of the fire coals, or of the gum arabic, carrying off the oxygen from the phoſphoric acid; which previouſly exiſted both in the calcareous earth of the ſelenite, and in the aſhes of the gum arabic.

Mr. Canton, in the Philoſ. Tranſact. Vol. LVIII. p. 337, publiſhed his making a pyrophorus by calcining oyſter-ſhells, and then mixing them reduced to powder with ſulphur, and recalcining them in cloſe veſſels. This powder after being expoſed to light, or heated by other means, became luminous in the dark for many minutes. By this proceſs the acid of phoſphorus exiſting in the animal ſhell had been decompoſed by the red hot ſulphur having robbed it of its oxygen; and thus the phoſphorus remained united with the calcareous earth.

M. Du Fay, in a memoir publiſhed in the year 1730, aſſerts from experiments, that all calcareous ſtones, whether they contain vitriolic acid or not, are capable of becoming luminous by calcination; with this difference only, that the pure calcareous ſtones require a ſtronger or repeated calcination; whereas thoſe, which contain an acid, as ſelenites, or gypſum, become phoſphoric by ſlighter calcination. M. Margraaf alſo aſſerts, that all kinds of calcareous ſtones may by calcination be rendered phoſphoric; but thinks, that the pure ones ſhould be previouſly ſaturated with an acid. Keir's Dict. Art. Phoſphorus. And laſtly, ſome kinds of fluor, which is known to conſiſt of calcareous earth and the fluor-acid, emit phoſphoric light on being heated ſlowly, but looſe it, when much ignited. (Kirwan's Mineralogy.) This material might probably as well as gypſum become uſeful in agriculture.

4. Theſe experiments, which ſhew that all common calcareous ſtones, which contain only carbonic acid, were rendered phoſphoric by calcination; but that thoſe which did contain a fixed acid, as gypſum, and fluor, were rendered phoſphoric with leſs difficulty, acquaint us firſt with perhaps one very important uſe of lime in agriculture. Secondly, with that alſo of gypſum, or alabaſter, which has lately been uſed in America and in Germany without previous calcination;

but

but which might probably be more ſucceſsful after calcination. And thirdly, with the probable uſe of fluor ſpar in its recent or calcined ſtate. As there is reaſon to believe, that the vegetable ſyſtem may abſorb phoſphorus from any of theſe materials; which phoſphorus may originally have been of animal origin, as well as that which exiſts in feces and urine. And laſtly, the uſe of recent ſhells or bones ground into powder, or of bone-aſhes, ſpread on land may be deduced; as they conſiſt almoſt entirely of phoſphorus and calcareous earth.

5. In the converſion of ſhells into limeſtone there ſeems to have been either ſimply an additional quantity of carbonic acid attracted from the air or from water during the proceſſion of ages, and added to the calcareous earth, or alſo a diminution of the phoſphoric acid. But an union of phoſphoric acid only with lime has lately been found to compoſe whole mountains in Spain, which is mentioned by Fourcroy, and is now termed phoſphate of lime, reſembling bone-aſhes. And M. Brumaire lately received from Spain a yellowiſh tranſlucent ſtone, called chryſolite by the jewellers, which he found to contain nearly equal parts of phoſphoric acid and calcareous earth, and to be a ſpar or cryſtallization of the phoſphate of lime. And as the limeſtone at Breedon has lately been diſcovered to contain equal parts of magneſia and lime, we may hope by greater attention to diſcover a mountain of phoſphate of lime in our own country. See Nicholſon's Journal 1798, p. 414.

From hence it would appear, that the immenſe quantities of limeſtone in the world, which was originally formed from the ſhells of ſubmarine animals, has during the long lapſe of time loſt more or leſs of its original phoſphoric acid, and acquired more or leſs carbonic acid. The carbon diſſolved in the atmoſphere or in the ocean having thus ſlowly decompoſed the phoſphoric acid in the elaboratory of nature without great heat, as it does in our crucibles in a ſhort time by the aſſiſtance of great heat.

It is probable that much phoſphorus may be conſumed in our inartificial mode of burning lime, which might be preſerved by calcining limeſtone in cloſe veſſels, and thus detaching the carbonic acid without admitting the aerial oxygen to the phoſphorus; but the advantage to agriculture of ſuch a proceſs can only be determined by experiment.

There are many inſtances given by Mr. Anderſon, and by Lord Kaims, of ſoils which are ſaid to have been for ages uncommonly fertile without addition of manures or culture. Theſe are plains near the ſhore in the county of Caithneſs, and in the Hebrides, and are ſaid to conſiſt almoſt entirely of ſhells broken into very ſmall particles, without almoſt any mixture of other ſoil. See Encyclop. Britan. Art. Agricult. Now the ſoil of an extenſive country called Lincoln Heath I obſerved ſome years ago to conſiſt in a great degree of powdered limeſtone, which like the Ketton limeſtone appeared in ſmall rounded particles, which I ſuppoſe had in remote times been diſſolved in water, and again precipitated; which ſhews a probable difference between this lime and recent ſhells in reſpect to their antiquity, and conſequently that the former muſt contain much of the original phoſphoric acid, and the latter only carbonic acid. And as Lincoln Heath was then eſteemed a very unproductive ſoil, there is reaſon to infer that the phoſphoric acid in recent ſhells is of greatly more ſervice to agriculture than the carbonic acid of alluvial limeſtone, or than calcined lime alone.

Hence it is probable, that a greater quantity of phoſphoric acid may exiſt in ſome marles than in others, as well as in ſome limeſtones; thus the appearance of recent ſhells exiſts in the lime near Loughborough in Leiceſterſhire, in the road to Nottingham, and in ſome marles called ſhell-marle; which muſt therefore probably contain much more phoſphoric acid, ſo as almoſt to reſemble the bones of animals; and may thus be more friendly to vegetation. A piece of land is mentioned by Mr. Anderſon, that, after a thick coat of marle laid on it, bore crops for thirty years without additional improvement, and I think it was called ſhell-marle. See Encyclop. Britan. Agricult.

6. A medical philoſopher, M. Bonhomme, has endeavoured to ſhew, that the hardneſs of animal bones depends on the quantity of phoſphoric acid united to calcareous earth, which they contain; and that the rickets, a diſeaſe in which the bones become too ſoft, is ſolely owing to the want of it, or to the exiſtence of the vegetable acid inſtead of it. Annales de Chemie, Vol. XVII. May we not conclude, that the preſence of phoſphoric acid in the vegetable ſyſtem muſt be of importance; becauſe it ſo univerſally exiſts in them, and may probably give firmneſs to liqueous as well as to oſſeous fibres? To which may be added, that M. Fourcroy believes, that the aſhes of burnt vegetables, which have been ſuppoſed to conſiſt of earth or clay, when the fixed alkali is waſhed from them, are principally calcareous phoſphorus, like thoſe of animal bones. The ſame is aſſerted by Lord Dundonald in his Connection of Agriculture and Chemiſtry, p 25, who calls the inſoluble part of vegetable aſhes a phoſphat of lime. This ſubject is worthy further inveſtigation.

VI. LIME.

Many of the principal uſes of calcareous earth in promoting the growth of vegetables have been already mentioned in this ſection, which we ſhall recapitulate with additions.

1. One great uſe of calcareous earth I ſuſpect to conſiſt in its uniting with the carbon of the ſoil in its pure or cauſtic ſtate, or with that of vegetable or animal recrements during ſome part of the proceſs of putrefaction; and thus rendering it ſoluble in water by forming an hepar carbonis, ſomewhat like an hepar ſulphuris produced by lime and ſulphur, as mentioned in No. 4. 7. of this Sect.; by which pro-

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ceſs I ſuppoſe the carbon is rendered capable of being abſorbed by the lacteal veſſels of vegetable roots.

The black liquor, which flows from dunghills, is probably a fluid of this kind; but I mean to ſpeak hypothetically, as I have not verified it by experiment; and the carbon may be ſimply ſupported in the water by mucilage, like the coffee drank at our tea-tables; or may be converted into an hepar carbonis by its union with the fixed alkali of decaying vegetable matter, or by the volatile alkali, which accompanies ſome ſtages of putrefaction. See No. 10. 3. of this Section.

2. A ſecond mode of its ſerving the purpoſes of vegetation I believe to be by its union with carbonic acid, and rendering it thus ſoluble in water in its fluid ſtate inſtead of its being expanded into a gas; and that thus a great quantity of carbon may be drank up by vegetable abſorbent veſſels.

In the practice newly introduced of watering lands by deriving ſtreams over them for many weeks together, I am informed that water from ſprings is generally more effectual in promoting vegetation than that from rivers; which though it may in part be owing to the azotic gas, or nitrogen, contained in ſome ſprings, as thoſe of Buxton and of Bath, according to the analyſis of Dr. Prieſtley, and of Dr. Pearſon; yet I ſuppoſe it to be principally owing to the calcareous earth, which abounds in all ſprings, which paſs over marly ſoils, or through calcareous ſtrata; and which does not exiſt in rivers, as the ſalts waſhed into rivers from the ſoil all ſeem to decompoſe each other, except the marine ſalt, and ſome magneſian ſalt, which are carried down into the ocean. The calcareous earth likewiſe, which is waſhed into rivers, enters into new combinations, as into gypſum, or perhaps into ſiliceous ſand, and ſubſides. Theſe ſolutions of calcareous earth in thoſe waters, which are termed hard waters, and which incruſt the ſides of our tea-kettles, may poſſibly alſo contribute

tribute to the nutriment of animals, as mentioned in Zoonomia, Part III. Article I. 2. 4. 2.

3. A third mode, by which lime promotes vegetation, I ſuppoſe may be aſcribed to its containing phoſphorus; which by its union with it may be converted into an hepar, and thus rendered ſoluble in water, without its becoming an acid by the addition of oxygen. Phoſphorus is probably as neceſſary an ingredient in vegetable as in animal bodies; which appears by the phoſphoric light viſible on rotten wood during ſome ſtages of putrefaction; in which I ſuppoſe the phoſphorus is ſet at liberty from the calcareous earth, or from the fixed alkali, or from the carbon of the decompoſing wood, and acquires oxygen from the atmoſphere; and both warmth and light are emitted during their union. But phoſphorus may perhaps more frequently exiſt in the form of phoſphoric acid in vegetables, and may thus be readily united with their calcareous earth, as mentioned in No. 5. 6. of this Section, and may be ſeparated from its acid by the carbon of the vegetable during calcination, and alſo during putrefaction, which may be conſidered as a ſlow combuſtion.

The exiſtence of a ſolution of phoſphoric acid and calcareous earth in the veſſels of animals is proved by the annual renovation of the ſhells of crab-fiſh, and by the fabrication of the egg-ſhells in female birds; and is occaſionally ſecreted, where it cements the wounds made on ſnail-ſhells; or where it joins the preſent year's growth of a ſnail-ſhell to the part, where a membranous cover had been attached for the protection of the animal during its ſtate of hibernation. And laſtly, it is evident from the growth of the bones of quadrupeds, and from the depoſition of callus to join them where they have been broken.

4. Lime in its pure ſtate is ſoluble in about 600 times its weight of water; and by a greater quantity of carbonic acid than is neceſſary for its cryſtallization, it is ſoluble in water in much greater quantities, as appears by the calcareous depoſition of the water at Matlock;

lock; and may I ſuppoſe ſupply a nutritious ſubſtance by uniting with mucilage or oil, either in the earth at the roots of vegetables, or on the ſurface of the ſoil, which may be gradually waſhed down to them.

If a ſolution of ſoap be poured into lime-water, the oil of the ſoap combines with the calcareous earth, and the cauſtic alkali is ſet at liberty, according to the experiments of Mr. Bertholet; (ſee Nicholſon's Journal, Vol. I. p. 170,) who concludes, that oil has a ſtronger affinity to calcareous earth than it has to fixed alkali. At the ſame time it appeared, that a ſolution of the mild or effervescent fixed alkali poured on this calcareous ſoap would decompoſe it by twofold elective attraction; as the carbonic acid of the mild fixed alkali unites with the calcareous earth of the calcareous ſoap, and the oil unites with the pure or cauſtic alkali.

Many arguments may be adduced to ſhew, that calcareous earth either alone, or in ſome of the ſtates of combination above mentioned, may contribute to the nouriſhment both of animals and vegetables. Firſt, becauſe calcareous earth conſtitutes a conſiderable part of them, and muſt therefore either be received from without, or formed by them, or both. Secondly, becauſe from the analogy of all organic life, whatever has compoſed a part of a vegetable or animal, may again after its chemical ſolution become a part of another vegetable or animal; ſuch is the general tranſmigration of matter!

5. There are other uſes of lime in agriculture, which may not be aſcribed to it as a nutritive food for vegetables, but from its producing ſome chemical or mechanical effects upon the ſoil, or upon other manures, with which it is mixed; as firſt, from its deſtroying in a ſhort time the coheſion of dead vegetable fibres, and thus reducing them to earth; which otherwiſe is effected by a ſlow proceſs, either by the conſumption of inſects, or by a gradual putrefaction. This is ſaid to be performed both by mild and by cauſtic calcareous earth, as in the experiments both of Pringle and Macbride. It is ſaid that unburnt

unburnt calcareous earth forwards the putrefaction of a mixture of animal and vegetable matter. But that pure lime, though it feemed to prevent putrefaction, deftroyed or diffolved the texture of the flefh. Thus I am informed, that a mixture of lime with oak-bark, after the tanner has extracted from it whatever is foluble in water, will in two or three months reduce it to a fine black earth; which if only laid in heaps, would require as many years to effect by its own fpontaneous fermentation or putrefaction. This effect of lime muft be particularly advantageous to newly enclofed commons when firft broken up.

Mr. Davis, in the papers of the Society of Arts, Vol. XVI. p. 122, afferts, that on a common, which had been previoufly covered with heath, but was otherwife very barren, the effect of lime was very advantageous for about ten years, during which time the vegetable roots might be fuppofed to have been diffolved and expended; but that a fecond liming he obferved produced no good effect. It is probable the good effect might not be fo great, but I fhould doubt the circumftance of its producing no good effect at all.

Mr. Browne of Derby has alfo an ingenious paper in the tranfactions of the Society of Arts, in which he afferts, that recent vegetables, as clover, laid on heaps and ftratified with frefh lime, are quickly decompofed, even in a few days. The heat occafioned by the moifture of the vegetables uniting with the lime I fuppofe quickens the fermentation of the vegetable juices, and produces charcoal in confequence of combuftion, fimilar to that frequently produced in new hayftacks, which if air be admitted burft into flame.

Secondly, lime for many months continues to attract moifture from the air or earth; which it deprives I fuppofe of carbonic acid, and then fuffers it to exhale again, as is feen on the plaftered walls of new houfes. On this account it muft be advantageous when mixed with dry or fandy foils, as it attracts moifture from the air above, or the earth beneath; and this moiſture is then abſorbed by the lymphatics of the roots of vegetables.

Thirdly, by mixing lime with clays it is believed to make them leſs coheſive; and thus to admit of their being more eaſily penetrated by vegetable fibres.

Fourthly, a mixture of lime with clay deſtroys its ſuperabundancy of acid, if ſuch exiſts; and by uniting with it converts it into gypſum, or alabaſter.

Fifthly, when lime is mixed with a compoſt of ſoil and manure, which is in the ſtate of generating nitrous acid, it arreſts the acid as it forms, and produces a calcareous nitre, and thus prevents both its exhalation and its eaſy elutriation.

And laſtly, freſh lime deſtroys worms, ſnails, and other inſects, with which it happens to come in contact, and with which almoſt every ſoil abounds.

6. The various properties of lime above deſcribed account for the great uſes of it on almoſt all lands; except perhaps ſome of thoſe which already abound with calcareous earth.

On riding from Beckingham to Sleaford, and from thence to Lincoln, I was informed by three or four farmers, that lime had been tried, but was believed to be of no ſervice in that country. Nor was I ſurpriſed at this obſervation, as I had ſeen fragments of alluvial limeſtone thrown out of every ditch on the road, which was of a looſe texture, conſiſting of calcareous ſand, like the Ketton limeſtone, rounded by friction, before it was conſolidated into a maſs, the upper ſurface of which was broken into fragments, when it was raiſed from the ſea by ſubterraneous fires, or by its cooling from a hot ſtate or its drying from a moiſt one.

Thus, as I had ridden over one ſingle alluvial limeſtone above ten miles broad and above twenty long, the broken ſurface of which appeared in the bottom of almoſt every ditch, I concluded, that the ſoil muſt be calcareous earth mixed only with ſome animal and vegetable

getable recrements, and that an addition of pure lime could probably not be of much advantage to the vegetables it ſupported. And the ſame I ſuppoſe muſt occur in thoſe ſituations, where the ſurface of the ſoil conſiſts almoſt totally of chalk, which is another kind of alluvial limeſtone; that is, which has been diſſolved in water in the early ages of the world, and again depoſited.

Yet even in ſome ſoils, which abound in calcareous earth, lime is eſteemed to be of ſervice; which may be owing both to its cauſtic quality, and to its being ſo finely pulverized. For a part of the water, which combines with it after calcination, gives out ſo much heat as to convert another part of it into ſteam; which breaks the calcined lime-lumps into a moſt ſubtile and impalpable powder, approaching even to fluidity, as mentioned in No. 4. 4. of this Section.

In the pariſh of Hartington in Derbyſhire there is a ſtratum of hard limeſtone, or marble, as I am informed, immediately beneath a ſhallow ſoil, and which in many places peeps through it; yet on ſome of this land an ingenious active agricultor has laid lime on the graſs in great quantity with prodigious advantage; and that he continues annually to improve by this means a conſiderable extent of land.

The difference between the hard limeſtone of this part of Derbyſhire, and the ſoft ſand-formed limeſtone about Lincoln Heath and Sleaford, may render the incumbent ſoil to be more or leſs mixed with calcareous earth; or they may abound more or leſs with phoſphoric acid, as mentioned in No. 5. 5. of this Section. But it may have happened, that ſome prejudices of the farmers, who gave me the information, might have led them to condemn the uſe of lime about Sleaford and Lincoln; and I ſhould again recommend it to their ſerious attention.

Another improper ſituation for the uſe of lime is ſaid to be on thoſe lands, which are too wet, and which therefore ſhould be previouſly drained; otherwiſe the lime is ſaid to coaleſce into a kind of mortar,

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and become ſo hard, that the tender plumula of growing ſeeds, or the fine extremities of their roots, can not eaſily penetrate it. This may occur more certainly in that kind of lime, which contains manganeſe, and is therefore capable of ſetting under water, as, I ſuppoſe, the barrow lime of Leiceſterſhire, and agnes lime near Aſhbourn in Derbyſhire.

7. The great and general advantage of lime in all ſoils and all ſituations, except ſome of thoſe which are already replete with calcareous earth, or are too moiſt, can only be underſtood from the idea already mentioned of its ſupplying actual nutrition to vegetables; and this ſeems more probable, as it contributes ſo much to the melioration of the crops, as well as to their increaſe in quantity. Wheat from land well limed is believed by farmers, millers, and bakers, to be, as they ſuppoſe, thinner ſkinned; that is, it turns out more and better flour; which I ſuppoſe is owing to its containing more ſtarch and leſs mucilage.

Hence we perceive another very important uſe of lime in cultivation of land may be owing to its forwarding the converſion of mucilage into ſtarch, that is, to its forwarding the ripening of the ſeed; which is a matter of great conſequence in this climate of ſhort and cold ſummers. See Sect. VI. 3. and XVI. 3.

In reſpect to graſs-ground I am informed, that if a ſpadeful of lime be thrown on a tuſſock, which horſes or cattle have refuſed to eat for years, they will for many ſucceeding ſeaſons eat it quite cloſe to the ground; which is owing, I ſuſpect, to the graſs containing more ſugar in its joints; or to the leſs acidity of all its juices.

8. There are not only ſome other bodies, which poſſeſs a calcareous baſe, beſides the common limeſtone, as gypſum, fluor, bone-aſhes, and perhaps vegetable aſhes; but there are others which are occaſionally united with carbonic acid, and may be detached from it by calcination, as the aerated barytes and magneſia. The laſt in its calcined ſtate may poſſibly be as uſeful in agriculture as the lime of calcareous

calcareous earth, with which I believe it is frequently mixed. For Mr. Tennant aſſured me a few days ago, that he had analyſed the limeſtone of Breedon in Leiceſterſhire, and found it to contain nearly as much magneſia as calcareous earth, beſides ſome manganeſe; which is nevertheleſs a lime much eſteemed in this country both for architecture and agriculture. As magneſia exiſts in ſea-water, and in ſalt ſprings, it may render theſe waters uſeful as a manure as well as the marine ſalt, which they contain. As ſteatites or ſoap-ſtone conſiſts principally of magneſia, perhaps this limeſtone of Breedon may be worth the attention of the porcelain manufactory.

This magneſian lime of Breedon is further worthy attention in the cultivation of land, and particularly where a ſoil abounds with vitriol of iron, or where it abounds with gypſum, as about Chelaſton on the banks of the Derwent, and from Nottingham to Newark on the banks of the Trent, as the magneſian earth would unite with the vitriolic acid, and leave an ochre of iron in one caſe, and lime in the other; at the ſame time a ſoluble ſalt, called Epſom ſalt, would be formed, which, according to the experiments of Dr. Home, promotes rapid vegetation. To ſow a few pecks of gypſum reduced to powder on graſs land, as is done in America; and then to ſow upon this twice or thrice as much Breedon lime, might be an experiment which might be advantageous in the part of Derbyſhire next to Leiceſterſhire, where both of them are to be obtained at no great expence.

VII. CLAY, METALLIC OXYDES, NITRE, SEA-SALT.

1. The too great adheſion of the particles of argillaceous earth or clay renders it in its pure ſtate unfit for vegetation; as the tender fibrils of roots can with difficulty penetrate it, whence it becomes much improved for the purpoſes of agriculture, when it is mixed with calcareous earth and with ſiliceous ſand, as in marle.

It is commonly believed that lumps of clay become meliorated by

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being expofed to froft in its moift ftate, which by expanding the water, which it contains, by converting it into ice is fuppofed to leave the particles of the clay further from each other. This however feems in general to be a miftaken idea, fince if the act of freezing be not very fuddenly performed, a contrary effect feems to occur, as noticed by Mr. Kirwan; who obferves, "that clay in its ufual ftate of drynefs can abforb two and a half times its weight of water without fuffering any to drop out, and retains it in the open air more pertinacioufly than other earths; but that in a freezing cold clay contracts more than other earths fqueezing out its water, and thus parting with more of it than other earths." Mineralogy, Vol. I. p. 9.

This curious circumftance, that water, as it cryftallizes, detrudes the clay, which is diffufed in it, correfponds with other facts of congelation. Thus when wine, or vinegar, or common falt and water, or a folution of blue vitriol in water, are expofed to frofty air; the alcohol, the acetous acid, the marine falt, and the calx of copper, are all of them detruded from the aqueous cryftals, and retreat to the central part of the fluid, or to that laft frozen, or into numerous cells furrounded with partitions of ice, as I have frequently obferved; whence it appears, that wet clay is in general rendered more folid and tenacious by being frozen, as well as when it is dried, and its moifture exhaled by too warm a fun; and by both thofe circumcumftances becomes lefs adapted to the purpofes of agriculture.

2. In moft clays a kind of effervefcence occurs, after they are turned over, and thrown on heaps, and thus acquire air into their inteftines, which renders them much fitter for the purpofes of vitrification; and thus forwards the proceffes of the brick-kiln and pottery. This greater facility to vitrify is probably effected by the union of oxygen with the iron, which moft clays contain; as oxydes of lead and manganefe are ufed in the more perfect vitrifications.

The calciform ores, or oxydes, of iron, manganefe, and zinc, are frequently found near the furface of the earth, where they have been united with oxygen by the paffing currents of the atmofphere; and have been fuppofed to have originated from the decompofition of vegetables and animal bodies, as mentioned in Botanic Garden, Vol. I. additional note 18. Iron has been detected in all vegetable and animal matters, manganefe in fome of them; and, if we poffeffed a teft for difcovering fuch minute particles of zinc, as the magnet difcovers of iron, it is probable, that zinc alfo would be detected in the vegetables, which grow over its beds.

As fome philofophers have lately contended for the great utility of oxygen in vegetation, as Humboldt and Von Uflar; who affirm from their experiments, that hyper-oxygenated muriatic acid ufed in fmall quantities promotes both the growth and irritability of plants; there is reafon to fufpect, that the calciform ores of iron, manganefe, and zinc, as well as minium, and other calces or oxydes of metals made by fire, and even burnt clays, when ftrewed on the ground, may contribute to vegetation by their parting with their abundant oxygen in a fluid, not in a gaffeous form; which uniting with carbon, or phofphorus, or nitrogen, without emitting perceptible heat or light, might fupply nutritious fluids to the roots of vegetables; further experiments are wanted on this fubject. But I am well informed, that a red ocher of iron, called raddle, has been ufed on fome lands with advantage in the north of Staffordfhire; and fhould recommend a trial of manganefe in thofe countries, where it abounds, as near Kingfbury, and near Atherftone in Warwickfhire; and a trial of lapis calaminaris, where it abounds, as near Matlock in Derbyfhire; and even of the calciform ore of lead, which is found in Anglefey, and on the top of fome other lead mines.

M. Humbold afferts, that he mixed many feeds into a kind of pafte with the black oxyde of manganefe, and poured over it the muriatic acid diluted with water, in the proportion of about fix of water to one of acid; and that much oxygen was thus difengaged, and occafioned ed quick vegetation. Journal de Phyfique, 1798. See No. 2. 8. of this Section.

3. When clays are turned up with the fpade, as is ufual in preparing them for the brick kiln, a kind of effervefcence occurs, as mentioned above; which is probably owing to the efcape of the azote of the air imprifoned in the interftices, as the oxygen unites with fome metallic particles in the clay; or to fteam raifed from the water in the clay by the heat fet at liberty from the combination of the oxygen and the iron. This union of oxygen with iron is curioufly almoft vifible in many granates or porphyries; which I have feen thinly fcattered in large nodules near Cannock in Staffordfhire, in the road from Lichfield to Shrewfbury; and on breaking them have obferved no appearance of iron on the newly divided furfaces; but which in a few days acquired an ochery appearance on them, which penetrated nearly half an inch. This can not but be afcribed to the oxygen of the atmofphere having united with the iron in thefe ftones, which by their fmell, when breathed upon, contain indurated clay, and having converted into an oxyde either the clay itfelf, or fome metallic particles included in it.

There is neverthelefs an exhalation from clay, and perhaps from moft foils, when they have been previoufly dried, and then fprinkled with water, as after a fhower in fummer, which has been fuppofed to be falubrious to invalids and convalefcents. This remarkably occurs, when dry clay is breathed upon even in its moft indurated ftate, as in granites and porphyries, by which criterion thefe ftones are immediately diftinguifhed from the filiceous and calcareous ones. This I imagine is produced by the heat fet at liberty by the combination of dry clay and water, like that produced in fo much greater degree by the combination of lime and water; and that this heat raifes a part of the acquired moifture into fteam, in which are diffolved the odorous particles; both which probably caufe the quick vegetation on clayey foils after the fhowers in fummer.

When

When marl, which confifts of clay, calcareous earth, and fand, which are frequently coloured red by iron, or blue probably by manganefe, is expofed in fmall lumps to the atmofphere; it is liable to crumble into powder, which I fuppofe to arife from a fimilar circumftance; that the oxygen of the atmofphere uniting with the clay, or the metallic particles it poffeffes, lets at liberty the fame gas, or fteam, which is feen to rife from clay, when thrown on heaps for the brick kiln or pottery; which breaks the lumps into powder, as the lumps of lime are broken into powder by the fteam, which is generated when water is thrown on them, by the heat fet at liberty by the combination of the lime and water.

This union of oxygen with the clay, or with the metallic particles mingled with it, I fuppofe to be much facilitated by expofing it to a red heat, as in burning bricks; while a greater heat may unite fo much oxygen with it as to turn it into glafs. Exactly fuch a procefs occurs in the production of minium; a certain quantity of heat with the contact of air combines fo much oxygen with the melted lead, as to form an oxyde; a greater quantity of heat converts it into glafs.

4. When clay is united with fo much oxygen by fire as to form a foft or imperfect brick, it poffeffes the power of promoting the generation of the nitrous acid in certain fituations; which is frequently feen like an efflorefcence on mouldering walls, having become by the addition of lime a calcareous nitre. The ufe of thefe foft bricks in the production of nitre is well known in Paris, where the rubbifh of old houfes is regularly purchafed for that purpofe; which before the revolution was a royal manufacture.

As thefe foft efflorefcent bricks from old houfes are known powerfully to promote vegetation, when pulverized and mixed with the foil; at the fame time that they are capable of producing the nitrous acid; I imagine, that the ufe of paring and burning the turf of fome newly enclofed commons depends on this circumftance. That is,

 that

that the heat emitted from the burning vegetable fibres unites oxygen with the clay; which latter forms more than half of the flices of turf, as they are dug from the ground. In other refpects the paring and burning of grafs grounds would certainly be a wafteful procedure; as much carbon is converted into carbonic acid, and difperfed along with the uninflamed fmoke or foot, and nothing left but the vegetable afhes. From thefe confiderations it would probably be worthy experiment in farms, where coal and clay abound, to burn the latter to a certain degree; which might fupply an exhauftlefs fource of profitable manure.

5. I have fufpected alfo, that this calcined clay, as it exifts in foft bricks, has a power of decompofing marine falt, as I once obferved in a cellar, where beef had been long falted on one fide of a nine-inch wall, the wooden falting-tub for which was attached to it; that a great efflorefcence appeared on the other fide of the wall, which I believed to be foffile alkali or natron. If this idea be juft, the foft bricks from old buildings, or clays fo far purpofely burnt, may in this manner be ferviceable to vegetation, by feparating the foffile alkali from the fea-falt, which is wafhed from decompofing animal and vegetable fubftances; which by converting carbon into an hepar carbonis, as lime is fuppofed to do in No. 6. 1. of this Section, might render it foluble in water, and capable of being abforbed by the lymphatic veffels of the roots of plants.

If clay calcined to a certain degree, and thus united with oxygen, poffeffes the power of decompofing marine falt, there is reafon to believe, when it is more flowly united with oxygen by its expofure to the atmofphere by the fpade or plough, that it may poffefs the fame property; and that this may have given rife to the very contradictory reports concerning the ufe of fea-falt in agriculture; as it may probably be of great advantage to clayey foils, but perhaps not fo to other foils. See Sect. XIV. 2. 8.

6. Another faline body, which readily unites with argillaceous earth

earth in the fire, is ſalt of urine, commonly called microcoſmic ſalt, which acts as a flux diſſolving clay with conſiderable effervefcence. Kirwan's Mineralogy, Vol. I. p. 9. This microcoſmic ſalt conſiſts of phoſphoric acid united with an ammonical, or with a calcareous baſe; and muſt in the latter caſe reſemble the phoſphat of lime, of which there are whole mountains diſcovered in Spain, as mentioned in No. 5. 5. of this Section; and of which many may probably be diſcovered in our own country. Now as the ſame combinations of matter, which are quickly formed by the heat of the chemiſt's furnaces, are often performed, though more ſlowly, in the elaboratory of nature; it is probable, that if this calcareous phoſphorus could be procured in this country, reduced to powder, and ſpread on our clay lands, that it might more than any other calcareous matter render them friendly to vegetation, like the aſhes of burnt bones; which experiment alone can determine.

7. As clay is leſs adapted to the growth of the roots of plants by the too great coheſion of its particles, this may be in ſome degree corrected by frequently expoſing it to air impriſoned in its interſtices, as by turning it over by the plough or ſpade. Another method is by planting on it ſuch vegetables firſt as are known to grow well in clay, as beans, and as their roots are afterwards left in the clay, they not only thus form tubes in it, ſo as to render the maſs leſs coheſive; but add to it ſo much carbon, and thus rather enrich than impoveriſh it. Add to this that the lower leaves of the denſe foliage of theſe vigorous vegetables are believed to give out much carbonic acid by their reſpiration in the ſhade ſimilar to the reſpiration of animals; which perpetually ſinking down upon the ſurface of the ſoil is believed to ſupply it with carbon; and thus alſo to render it more nutritive to other vegetables, which may afterwards grow upon it.

Lord Kaimes, who allows that clay, if it be moiſtened after it has been pulverized, becomes on drying as indurated and coheſive as before, aſſerts, that this does not happen, if it be moiſtened with the fluid, which eſcapes from dunghills; which may be owing both to the carbon, and to the fixed vegetable alkali, which that fluid contains. And alſo adds, that lime will prevent the coheſion or induration of clay, and therefore greatly improves argillaceous ſoils for all the purpoſes of agriculture.

8. When clay abounds with vitriolic acid ſo as to be converted into alum, it becomes very unfriendly to vegetation. In this ſtate it is believed much to counteract the proceſs of putrefaction in animal bodies, as is ſaid to have happened in ſome burying grounds. This it may effect by uniting with the ammonia generated by putrefaction the moment it is formed, or by preventing its production; as when the ſalt of Neville Holt water in Leiceſterſhire, which I ſuppoſe is alum, is mixed with very putrid blood, as I once witneſſed, the putrid ſcent was inſtantly deſtroyed, as I ſuppoſe the argillaceous earth was precipitated.

Where this acid or aluminous clay abounds, it is believed to check the vegetation of trees as well as of herbaceous plants by eroding the fine extremities of their roots, as mentioned in Sect. II. 9. which is perhaps beſt to be remedied in gardens by wood-aſhes or ſoap-ſuds, and in larger fields by mixing lime, or chalk in powder, or the ſweepings from roads, which are repaired by limeſtone, with theſe aluminous clays. Or laſtly, where it can be procured, by mixing with them ſuch lime as that of Breedon in Leiceſterſhire, which conſiſts of equal parts of magneſia and calcareous earth, which would thus fabricate what has been termed Epſom ſalt, which is ſaid to be friendly to vegetation.

VIII. MANURES BY SPONTANEOUS DECOMPOSITION.

We ſhall now conſider more generally the decompoſition of organized matter, which vegetable and animal bodies ſpontaneouſly undergo,

dergo, when they ceafe to live. The proceffes of this decompofition have commonly been divided into the vinous, acetous, and putrefactive fermentations; which have been fuppofed uniformly to fucceed each other. But it is more probable, that different kinds or parts of dead organized matter may be fubject to many different kinds of chemical changes, and that thefe may vary with the degrees of heat, and the quantity of water, and of air, with which they are furrounded.

1. In the ftomachs of animals a faccharine procefs precedes the vinous fermentation; which laft only occurs, when the animal power of digeftion or abforption is for a time fufpended. A fimilar procefs occurs in the germination of vegetable roots, whereby meal is converted into fugar, as in the malt-houfe; and in the gradual ripening of apples and pears, after they are plucked from the tree; but all thefe may be faid to be ftill alive; and this change of meal or of mucilage into fugar may thus be efteemed a vegetable rather than a chemical procefs.

The art of cookery, by expofing vegetable and animal fubftances to heat, has contributed to increafe the quantity of the food of mankind by converting the acerb juices of fome fruits into fugar, as in the baking of unripe pears, and the bruifing of unripe apples; in both which fituations the life of the vegetable is deftroyed, and the converfion of the harfh juice into a fweet one muft be performed by a chemical procefs; and not by a vegetable one only, as the germination of barley in making malt has generally been fuppofed.

Some large round auftere pears were yefterday, November 20, fhewn me after having been nine hours in the oven behind a kitchen fire covered fome inches with water in a fteam-pot. On tafting them they were fweet, and foft, and appeared to have had at leaft the heat of boiling water. They were replaced in the oven, and kept in it twelve hours longer; and then became nearly as fweet as fyrup or treacle; which might in part have been occafioned by the evaporation of half the water. From this curious circumftance there feems reafon to conclude, that in a degree of heat about that of boiling water the faccharine procefs may fucceed; and at the fame time that the procefs of fermentation may be prevented from exifting; which I hope may induce fome chemical philofopher to inveftigate by experiments this curious and important fubject.

Some circumftances, which feem to injure the life of feveral fruits, feem to forward the faccharine procefs of their juices. Thus if fome kinds of pears are gathered a week before they would ripen on the tree, and are laid on a heap and covered, their juice becomes fweet many days fooner. The taking off a circular piece of the bark from a branch of a pear-tree caufes the fruit of that branch to ripen fooner by a fortnight, as I have more than once obferved. The wounds made in apples by infects occafion thofe apples to ripen fooner; caprification, or the piercing of figs, in the ifland of Malta, is faid to ripen them fooner; and I am well informed, that when bunches of grapes in this country have acquired their expected fize, that if the ftalk of each bunch be cut half through, they will fooner ripen.

The germinating barley in the malt-houfe I believe acquires not half its fweetnefs, till the life of the feed is deftroyed; and the faccharine procefs then continued or advanced by the heat in drying it; though I have lately been informed that fome grains of malt will vegetate after having been dried in the ufual manner, which however may have been owing to their not having been previoufly fuffered perfectly to germinate. Thus in animal digeftion the fugar produced in the ftomach is abforbed by the lacteals, as faft as it is made; otherwife it ferments and produces flatulency; fo in the germination of barley in the malt-houfe fo long as the new plant lives, the fugar I fuppofe is abforbed, as faft as it is made; but that which we ufe in making beer is the fugar produced by a chemical procefs after the death of the young plant, or which is made more expeditioufly than the plant can abforb it.

It

It is probably this faccharine procefs, which obtains in new hay-ftacks too haftily; and which by immediately running into fermentation produces fo much heat as to fet them on fire. The greateft part of the grain, or feeds, or roots, ufed in the diftilleries, as wheat, canary feed, potatoes, are not I believe previoufly fubjected to germination; but are in part by a chemical procefs converted into fugar, and immediately fubjected to vinous fermentation. And it is probable, a procefs may fometime be difcovered of producing fugar from ftarch or meal; and of feparating it from them for domeftic purpofes by alcohol; which diffolves fugar but not mucilage; or by other means.

This then may be termed the faccharine fermentation, and may exift I fuppofe beneath or upon the earth in the beginning of fome fpontaneous vegetable decompofitions, previous to the vinous fermentation; and may fupply thus a very nutritive material to vegetation; fimilar to that which the embryon plants in the feeds of many fruit-trees acquire from their fruits; and to that, which the embryons in many farinaceous feeds acquire from the fpontaneous change of the meal in their cotyledons; though perhaps in lefs quantity and purity.

2. A fecondary procefs to this I fuppofe to be the vinous fermentation, in which much carbon becomes united to oxygen; and probably at the very inftant of their combination, while they are yet in the form of a liquid, and not of a gas, they become abforbed by the roots of plants. The heat, which is perceived in the hotbeds, which are ufed for the growth of cucumbers and melons, is produced by this union of oxygen and carbon, or by the generation of fome other acids, as of phofphorus, or nitre.

That this heat is owing to the atmofpheric air combining with fome inflammable bafe, and producing acidity of fome kind, appears from the following experiment. A few years ago a gardener told me that a hot-bed, which he had made of tanner's bark with fome

horfe

horſe dung and ſtraw, was become too cold for the growth of his pots of cucumbers. He was deſired ſimply to turn over the bed, and ſhake every part of it in the air with his fork, as he lightly replaced it. This was complied with, and in a few days I obſerved by touching a ſtick, which had for ſome hours been inſerted into it, that it had acquired the uſual heat of a hot-bed.

This addition of heat was doubtleſs acquired from the air, which was recently included in the interſtices of the bed by its being turned over, broken into ſmall pieces, and expoſed to the atmoſphere; whence new acids ſeem to have been generated, and carbon, and perhaps phoſphorus and nitrogen, rendered ſoluble in water. Great heat is produced from the union of oxygen with thoſe baſes of acidity, which in large ſtacks of new hay is often known to excite real combuſtion; the violent fermentation of which may be partly owing to the ſugar, which is depoſited in the joints of graſs before the ſeeds are ripe for their nouriſhment, and partly to a chemical production of ſugar, as above deſcribed.

3. In the putrefactive proceſs carbon is not only converted into carbonic acid, as above related; but there appears to be a decompoſition of water, as is known by the ſmell of hydrogen; and it is probable, this inflammable body may unite with carbon, as in hydrocarbonate gas, and thus render them both ſoluble in water, and abſorbable by the veſſels of vegetable roots, without their paſſing into an acid or gaſſeous form, and may much contribute to the nutriment of vegetables.

4. There alſo appears at the end of the putrefactive proceſs to be a junction of azote with oxygen producing the acid of nitre, which probably may contribute much to promote vegetation. This appears from the mode of procuring that acid in France and Pruſſia, and which might be ſucceſsfully practiſed under every ſhed in our own farm-yards; as it conſiſts in a due mixture of vegetable and animal recrements with ſoil, frequently turned over to expoſe it to the air,

while

while it is defended by a ſhed from the ſunſhine and rain; which is thus at the ſame time adapted to produce the quickeſt vegetation, and to generate the nitrous acid.

The oxygen, which compoſes nitrous acid, is believed to adhere more weakly to its baſe the azote, than in the compoſition of other acids. On this account it ſo readily explodes by its junction with carbon in a given degree of heat. This looſe adherence of the oxygen in nitrous acid, like that of hyper-oxygenated marine acid, and of the oxygen in the ore of manganeſe, and of ſome other metallic oxydes, may adapt them to promote vegetation by their more readily parting with this material ſo eſſential in the compoſition of plants.

5. From the above obſervations it appears, that when the ſoil is turned over by the ſpade or plough, and thus acquires atmoſpheric air in its interſtices, and in conſequence becomes warm by the production of new acids, that the ſeeds or plants ſhould be inſerted as ſoon as convenient, for the purpoſe of their receiving the moſt ſalutary effect of thoſe operations. Nor ſhould this be obſerved only in black garden mould, or well manured glebes, where carbon or phoſphorus may be ſuppoſed to abound, and a proper diſpoſition for the production of the nitrous acid, but in thoſe clays alſo which are pure enough for the brick-kiln or the pottery.

IX. MANURES BY CHEMICAL DECOMPOSITION.

The uſe of fire and water contributes to increaſe the nouriſhment of mankind by rendering many vegetable materials innocuous, and others digeſtable in the animal ſtomach; and ſeems particularly efficacious in promoting the ſaccharine proceſs, and in producing mucilage from griſtles, horn, hair, and perhaps even from bones by means of Papin's digeſter. Whether this art could be advantageouſly uſed for the purpoſe of rendering manures capable of being abſorbed by vegetable roots in a ſtate of leſs decompoſition, than by the ſlow proceſs of putrefaction, is a queſtion of curioſity and utility.

Sugar and mucilage are certainly abſorbed by vegetables without their being reſolved into the elements, from which they were compoſed; as appears in the ſap-juice which flows from the wounds of birch and maple trees in the vernal months; which I am informed will paſs into fermentation and produce wine; a proceſs which ſome modern chemiſt affirms cannot be effected by ſugar alone without the addition of mucilage. The abſorption of mucilage ſeems to occur in the germination of many ſeeds, as of barley; a part of the meal of the cotyledon is evidently converted into ſugar, but another part of it is probably abſorbed in the form of mucilage; ſome of which oozes on breaking the plumula; and in the growth of thoſe ſeeds, which contain oil, as in almond, hemp, rape, and line-ſeed, it is probable, a part of the undecompoſed oil may be abſorbed by the umbilical veſſels of the embryons in thoſe ſeeds.

It hence ſeems credible, that by the uſe of heat and water the art of cookery might furniſh mucilage, ſugar, and oil, from vegetable or animal materials; which might be converted into ſap-juice or chyle, without their being previouſly reduced into their elements; and might thus facilitate the more luxuriant growth of plants, as they contribute more to fatten animals, than materials of leſs combination.

2. To this might be added, that the putrefactive proceſs may be forwarded by heat in ſome materials by deſtroying the life of the material; as in roaſting apples and pears, and in killing the roots of potatoes, or the ſeeds of corn. Thus Mr. D——, a friend of mine, had twenty ſtrikes of potatoes, which he wiſhed to dry on a malt-kiln, hoping to render them more like the meal of wheat, and better to preſerve them during the ſummer-months. Whether they were ſufficiently dried he did not attend to; but they were carried into a granary, and laid on heaps; and in a week or two became ſo putrid,

that

that the ſmell was inſufferable, his ſwine refuſed to eat them, and he was obliged to add them to the manure of the dunghill.

That potatoes, which have undergone a certain degree of heat, contribute more to fatten all kinds of animals, ariſes from the acrimony of their rinds being deſtroyed, and from their auſtere juices being converted into mucilage, and perhaps a part of their mucilage into ſtarch, and are hence ready for the ſaccharine and oily proceſſes of animal digeſtion. A very convenient method of expoſing them to ſteam is deſcribed in a late ingenious publication of the Agricultural Society. A ſmall boiler is ſet in brick work under a ſhed, ſo that the flame of wood or coal may paſs ſpirally round it. It ſhould be covered with a double lid of tin or wood to prevent much heat from eſcaping; and may have a ſand-joint to keep the ſteam in, or a little moiſt clay, or even a wet flannel put circularly round the cover may anſwer this purpoſe.

Near this furnace is to be fixed a large barrel on one of its ends, with a cover on the other end; which may be occaſionally opened to admit potatoes, and cloſed again ſo as to confine the ſteam, which is to be derived into it from the boiler by a double pipe one within the other, of tin or wood, about two inches in diameter. By theſe means a large quantity of potatoes may be rendered much more nutritive to animals, and I ſuppoſe to vegetables (if they were uſed as manure), as they may thus probably be abſorbed by their lacteals or lymphatics without being ſo much decompoſed as by the putrefactive proceſs; and thus produce nutriment in leſs time, and by leſs labour of digeſtion.

If the ſteam could be made hotter than boiling water, which it poſſibly may in the veſſel above deſcribed, if the water in it riſes but a few inches, and the ſteam after it is produced, is heated above 212 degrees by the ſides of the boiler above the water, round which the flame plays ſpirally, the ſteam thus made hotter might probably render the potatoes more mucilaginous or more ſtarchy.

3. A ſtill more effectual method of diſſolving hard vegetable and animal ſubſtances, and rendering them nutritive, might be by digeſting them for ſome time in water raiſed to a much greater heat than that of boiling. This is to be done in a cloſe veſſel, called Papin's digeſter; in which it is ſaid, that the confined water may be made red hot; and will then diſſolve hair, horns, hoofs, bones, tortoiſe-ſhell, and all animal, and perhaps many vegetable matters; which might thus facilitate their decompoſition for the purpoſes of manures, or for the nutriment of many animals; and might even contribute to the food of mankind in times of ſcarcity. This veſſel ſhould be made of iron, and ſhould have an oval opening at top, with an oval lid of iron larger than the aperture. This lid ſhould be ſlipped in endways, when the veſſel is filled, and then turned, and raiſed by a ſcrew above it into contact with the under edges of the aperture. There ſhould alſo be a ſmall tube or hole covered with a weighted valve to prevent the danger of burſting the digeſter.

4. Other materials might be rendered more eaſily digeſtible, and thence more nutritive to animals, and perhaps to plants, by mechanic trituration as well as by cookery; if the labour and expence were not too great; as the grinding of graſſes, ſtraws, and farinaceous ſeeds into powder between mill-ſtones; which have been called the artificial teeth of ſociety. It is probable, that ſome ſoft kinds of wood ground into powder, and eſpecially when they have undergone a kind of fermentation, and become of looſer texture, or boiled to deſtroy their acrimony, might be rendered uſeful food for ſwine or horſes, and even for mankind in times of famine.

Nor is it improbable, that hay, which has been kept in ſtacks, ſo as to undergo the ſaccharine proceſs, may be ſo managed by grinding and by fermentation with yeaſt like bread, as to ſerve in part for the ſuſtenance of mankind in times of great ſcarcity. Dr. Prieſtley gave to a cow for ſome time a ſtrong infuſion of hay in large quantity for her drink, and found, that ſhe produced during this treatment

above

above double the quantity of milk. Hence if bread cannot be made from ground hay, there is great reafon to fufpect, that a nutritive beverage may be thus prepared either in its faccharine ftate, or fermented into a kind of beer.

It may be here obferved, that it is believed by fome, that feeding horfes with ground corn, as with the flour of beans or oats, does not ftrengthen them nearly fo much as by giving them the fame quantity of oats or beans whole. Parkinfon, Exper. Farmer, Vol. I. p. 227. It is afferted alfo that foup, with the flefh-meat boiled down into a fluid mafs, will give much lefs ftrength to a man, than he would acquire by eating the folid meat, of which the foup was made. The reafon of both thefe feems to arife from the faliva being well mixed with the mafticated food, and in greater quantity; which therefore becomes more animalized aliment, than that diffolved in water alone, and is more eafily converted into nutriment.

In times of great fcarcity there are other vegetables, which though not in common ufe, would moft probably afford wholefome nourifhment, either by boiling them, or drying and grinding them, or by both thofe proceffes in fucceffion. Of thefe are perhaps the tops and the bark of all thofe vegetables which are armed with thorns or prickles, as goofeberry-trees, holly, gorfe, and perhaps hawthorn. The inner bark of the elm-tree makes a kind of gruel. And the roots of fern, and probably very many other roots, as of grafs and of clover, taken up in winter, might yield nourifhment either by boiling or baking, and feparating the fibres from the pulp by beating them; or by getting only the ftarch from thofe which poffefs an acrid mucilage, as the white briony.

The grinding of bones to powder has already been applied to agriculture, and the chopping of woollen rags; and I fuppofe the trituration of alabafter, and of chalk, and of foft bricks, and probably of iron ochres, manganefe, and calamy, might well repay the labour;

after

after a few experiments had been inſtituted to determine the quantity, which ſhould be ſtrewed on different ſoils.

X. MANURES BY INSECT PROPAGATION.

1. That the continual growth and decay of animal and vegetable nature increaſes the quantity of ſuch matter, as is fit for the reproduction of organized bodies, is evinced by the increaſing fertility of cultivated countries; ſince even in theſe a great quantity of the annual recrements of decompoſed animals and vegetables are waſhed by rains from the ſoil, and carried down the rivers into the ocean; and in many ſituations of ſoil in Africa and America, which have been but lately cultivated, there exiſts a wonderful fertility from the aggregate remains of vegetable and animal bodies; which have for uncounted ages ariſen and periſhed there; and which have either left moraſſes, where they could not part with their ſuperabundant water; or a fertile earth, ſuch as in our gardens and church-yards, where the declination of the ground was more favourable.

Some countries on the contrary once highly cultivated and very populous are in proceſs of time become deſerts of ſand; as many parts of Syria, and the diſtricts about Palmira, and Balbec. This has probably been owing to the want of the neceſſary moiſture in thoſe warm and ſandy regions; which was formerly ſupplied by artificial derivations of water; but which ceaſed, after their inhabitants were deſtroyed by war and tyranny; and ſecondly to the rapid ſtreams occaſionally poured over them by the monſoon floods; ſimilar to thoſe which impoveriſh Abyſſinia and Nubia, while they fertilize the flat and ſhowerleſs provinces of Egypt.

We might add, that all calcareous ſtrata are now believed to have been produced by ſhells depoſited by aquatic animals in the early ages of the world; and that the materials, which conſtitute the ſtrata above them, have afterwards been formed by the recrements of terreſtrial animal and vegetable bodies. Whence it may be concluded, that vegetables and animals during their growth increaſe the quantity of matter fit for the more nutritive food of organized bodies, or of that which is leſs decompounded; while they muſt at the ſame time occaſionally form or elaborate a part of the materials, of which they conſiſt, from the ſimple elements of hydrogen, nitrogen, carbon, phoſphorus, ſulphur, and oxygen; into which modern chemiſtry has reſolved them by analyſis.

And laſtly, that vegetables can acquire nutrition from water and air alone with the carbonic acid, which floats in them, appears by the experiments of thoſe philoſophers, who have nicely encloſed the roots of ſome plants in pots, and moiſtened them with diſtilled water; and from hence we learn an eſſential diſtinction between vegetable and animal nature; the former can elaborate the two univerſal elements of water and air into nutritive juices, whereas the latter is neceſſitated to ſeek more compound nutriment, and to live upon the vegetables, which have produced it.

2. One method therefore of increaſing manures may be by repeatedly propagating and deſtroying vegetable crops; as by raiſing thoſe of quick growth, and ploughing them again into the ſoil during their ſaccharine and mucilaginous ſtate, before they ripen their ſeeds; as of vetches, and buck-wheat; vicia and polygonum; and thus producing a ſucceſſion of crops by the partial decompoſition of the preceding ones. And it is probable that this proceſs might be much improved by ſtrewing lime over the recent vegetables, at the time of ploughing them in, as is ſhewn in No. 6. 5. of this Section.

3. Another mode by which vegetable matter may be decompoſed in the ſummer months, and at the ſame time the quantity of manure increaſed, is by the depredation of inſects, as is ſeen in wood, which is ſo far decompoſing as to become tender, and is then conſumed by various kinds of inſects, whether it be buried beneath the ſoil, or expoſed

posed to the air. And I suspect, that the excrement and the bodies of such insects would supply more nutriment to vegetable roots, than if the vegetable recrements were left to their spontaneous or chemical dissolution; as I suppose the bitter excrementitious powder in a filbert, and the well fed maggot, before it erodes its way out, would fertilize more barren soil than an emulsion of the kernel.

An ingenious observer of nature conveyed water on a dunghill in the summer months in such quantity, as to make a kind of semi-fluid chaos, for the purpose of animating the whole mass. It became full of insects, and was used in the autumn as manure, and he believed with much greater powers, than it would have otherwise possessed.

Hence in the summer months a manure-heap may be advantageously supplied with water for the purpose of encouraging the propagation and nourishment of myriads of insects; but in the winter season it should not be exposed to much moisture; or that which drains from it should be derived spontaneously on lower grounds, or conveyed to higher ones by pumps or water carts; as it probably consists of a solution of carbon by means of vegetable alkali; or of a mixture of it in water by mucilage; and is thought to fertilize the ground more than the other parts of the manure heap. In the transactions of some provincial Society there is an account of much fixed vegetable alkali having been obtained from the evaporation of the water, which oozed from dunghills; and M. Rouelle has observed, that fixed alkali dissolves a considerable quantity of charcoal by fusion. Fourcroy's Elem. of Chemist. Vol. IV. p. 125.

4. Another great source of insect-manure may be obtained from the myriads of small fish, by those who live near the ocean; which by mixing them with soil so as to make what is termed a compost, will much add to the fertility of the land, on which it is afterwards spread, more so perhaps than any other material except the flesh of land-animals. In China it is said that the spawn of fish in the proper season

is

brought to market, and purchafed for the purpofe of peopling the floods on their rice grounds with fifh, part of which becomes large enough to be fried and eaten by the land cultivator; and the reft ferves the purpofe of fertilizing the foil, when the floods are drawn off, by their death and confequent decompofition.

XI. PRESERVATION OF MANURES.

1. The fertility of all countries depends on the faving and ufing thofe kinds of matter, which are fit for the reproduction of organized bodies. There is a proverb in China, that for this purpofe a wife man faves even the parings of his nails, and the clippings of his hair.

One great wafte of manure in this country, and in moft others, is from the frequent rains wafhing down the diffufible and foluble parts of the foil into the muddy rivers; fo that every flood from fudden fhowers carries into the fea many thoufand pounds worth of the matter of fertility; and thus diminifhes fo much the food of terreftrial animals, however it may add to the fuftenance of marine ones. The Delta of Egypt, and a diftrict in South America near the foot of the Andes mentioned by Ulloa, are faid by the fituation of the furrounding country to be free from rain, though they have frequent dews; and to this circumftance they may in part owe their increafing fertility.

In this country the fnow-floods, which occur after a continued froft, are lefs injurious than thofe from rains; as the ftreams of water from the upper furface of the diffolving ice flows over the under furface of it not yet diffolved; and the foil is not agitated as in rain by the percuffion of the defcending drops; infomuch that in fnow-floods the rivers are fcarcely muddy; whence thefe floods may be readily diftinguifhed from land-floods by the eye, and are much lefs injurious.

Great attention fhould therefore be fhewn to the preventing fmall ſhowers from waſhing away the ſoluble parts of good ſoil. For this purpoſe all hills ſhould be ploughed horizontally, and not in aſcending and deſcending furrows. Deſcending plains of graſs-ground might alſo be laid with horizontal ridges and depreſſions; by which management ſhowers will lie a few hours in the horizontal furrows or depreſſions, and either exhale or ſoak into the ground; and in very wet ſeaſons theſe may eaſily by the ſpade be opened into each other, if the water is found to lie too long upon them, ſo as to produce too much cold by its evaporation, or too great ſoftneſs by its abſorption into the ſoil.

2. Secondly, the manures of towns and cities, which are all now left buried in deep wells, or carried away by ſoughs into the rivers, ſhould be removed by a police, which is ſaid to exiſt in China; and carried out of towns at ſtated intervals of time for the purpoſes of agriculture; which might be performed in the night, as is done in Edinburgh; or by means of large baſons or reſervoirs at the extremities of the common ſhores, or ſoughs for the reception of the manure, before it is waſhed into rivers. See Embaſſy to China by ſir G. Staunton, Vol. III. p. 308, 8vo. edit.

It has been believed by ſome writers in the American Medical Repoſitory, that the peſtilential fever, which has of late infeſted that country, was in part produced or propagated by the filth of the ſtreets of New York. Dr. S. L. Mitchill adds to his chemical remarks on manures, "it muſt be welcome intelligence, that the collected maſs of nuiſance, which we are now with ſuch happy ſucceſs engaged in removing from the city of New York, is convertible by the powers of vegetation from poiſon to wholeſome articles of food; and thus the purity and healthineſs of the towns may contribute to the thriftineſs and wealth of the ſurrounding country." Medical Journal, No. I.

3. Thirdly, there ſhould be no burial places in churches or in church-yards, where the monuments of departed ſinners ſhoulder

God's

God's altar, pollute his holy places with dead men's bones, and produce by putrid exhalations contagious difeafes among thofe who frequent his worfhip. But proper burial grounds fhould be confecrated out of towns, and divided into two compartments, the earth from one of which, faturated with animal decompofition, fhould be taken away once in ten or twenty years, for the purpofes of agriculture; and fand or clay, or lefs fertile foil, brought into its place.

A great rife of the foil, from the remains of the bodies entombed in it, is feen round the churches of almoft all populous towns; fo as to have rendered it neceffary to defcend by feveral fteps into thofe churches, which were originally built fo as to require fteps to afcend into them; as may frequently be feen by the bafe of the architecture. Nor would the removal of this earth, if the few bones, which might be found, were again buried for a further decompofition, be likely to fhock the relations of the deceafed; as the fuperftition concerning the earth, from which we rofe, and into which we return, has gradually vanifhed before the light of reafon; as occurred about thirty years ago in removing much rich earth from the clofe of the cathedral at Lichfield, and more lately in changing a burying ground at Shrewfbury; both which were executed without fuperftitious terror, or popular commotion.

4. Fourthly, a great wafte of the materials of fertility occurs in all countries, and cannot eafily be avoided, in the confumption by fire of fo much wood inftead of coal. Whence the mucilage, and other nutritious juices, which exift in the fire-wood, are decompofed into their elements; and the carbon united with oxygen is diffufed in the atmofphere, and in part carried by the winds into the furrounding ocean; inftead of the manures occafioned by the flow decompofition of it upon or beneath the foil, or by the depredation of infects; which might fupply lefs decompofed nutriment to the abforbent roots of plants.

This may be more eafy to conceive, if we compare the little vegetable

table nutriment, which could be derived from the ſmall quantity of aſhes left from a cart-load of burnt-ſtraw, with that which would ariſe from the ſame quantity of ſtraw mixed with ſome animal recrements, and made into a manure heap. A ſtill greater diminution of uſeful manure would be made by burning ſhavings or raſpings of horn, or woollen rags, or hair, or fleſh; as a nutritive mucilage would be thus decompoſed into its elements, which might otherwiſe have been gradually diſſolved beneath the ſoil, and abſorbed by the roots of vegetables nearly in an unaltered ſtate; as jellies and mucilage are known to be drank up by the lacteals of animals; and, when drank in too great abundance, to appear almoſt unchanged in their urine.

It muſt hence appear, that the numerous fires of a great city, if ſupplied with wood inſtead of coals, as in Paris, muſt very much impoveriſh a great part of the country which ſupplies it; not only in the neceſſity of uſing large tracts of land for the growth of fire-wood, but alſo becauſe ſo ſmall a part of it returns as manure. There is a provident adage of general benevolence, "Burn nothing which any animal will eat;" that is, "Burn nothing which may nouriſh animals by its digeſtion in their ſtomachs." May not the ſame benevolent idea be extended to the vegetable world, and ſay, "Burn nothing which may nouriſh vegetables by its ſlow decompoſition beneath the ſoil, which conſtitutes their ſtomachs."

5. It may be a matter of uſe as well as of curioſity to aſcertain the ſituations and circumſtances moſt favourable for promoting the ſpontaneous decompoſition of vegetable ſubſtances; which may conſiſt perhaps in the due quantity of air, water, and heat, with a ſufficient proportion of animal ſubſtances, and finally an admixture of lime toward the end of the proceſs.

1. In a cellar covered with an arch of bricks, and cloſed with a very ſtrong door, I once obſerved, that a deal ſhelf two inches in thickneſs was decayed, ſo as to fall down with ſome wine bottles on

it,

it, in about four years. This fudden decay I believed to have been owing to the unchanging moifture of the board, and at the fame time to its expofure to unchanged air without the power of much exhalation; by which a flow fermentation was induced, and a confequent flow putrefaction, unchecked by the extremes either of heat or cold.

For the fame reafon I fuppofe the wooden fupporters of bridges decay firft juft above the furface of the water; and pieces of timber buried but a few inches under ground, which are there expofed to the influence both of water and air, go quicker into fermentation, and confequent putrefaction, than thofe pieces of timber, which are many feet buried beneath the foil, or immerfed deep in water; which in that fituation continue unchanged for ages. The fame feems to occur in the vinous fermentation, which is inftantly checked, if not totally ftopped, by bunging the barrel, or corking the bottle, which contains it, and thus precluding the accefs of atmofpheric air.

2. From hence it may be concluded, firft, that the vegetable and animal fubftances, which we wifh foon to become decompofed by the fermentative and putrefactive proceffes, fhould be expofed to an uniform moifture, though not covered deep with water; as is generally practifed in the firft part of the preparation of hemp or flax, which is defigned to diffolve the mucilage, and the cellular membrane of thofe vegetables, without injuring the ligneous fibres. And that they fhould be fo far accumulated as not too much to exhale; yet not to lie in fuch large heaps, as entirely to preclude the accefs of air from the interior parts of them.

The manures of great farms fhould therefore be occafionally removed from the fold-yards, or large refervoirs of it, and laid in fmall heaps not only to increafe its furface expofed to the external atmofphere, for the purpofe of exciting greater fermentation, which is a flow combuftion; but alfo that air may be imprifoned in the interftices of thefe manure-heaps, as mentioned in No. 8. 2. of this Section.

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It ſhould then be uſed on or in the ſoil, as it afterward loſes much of its nutritive qualities by evaporation, or ſinking into the ground, or draining away.

3. A due degree of heat is neceſſary for the commencement of fermentation and putrefaction, as both vegetable and animal materials, as fruit or fleſh, may be preſerved for years if kept in an ice-houſe below the freezing point of 32. And alſo, I am told, if they could be kept in an uniform degree of heat above the boiling point of 212. After the commencement of either of theſe proceſſes a quantity of heat is evolved from the combination of the oxygen and carbon, which contributes to forward the proceſſes by promoting the union of the next particles of oxygen and carbon; which may thence be compared to a ſlow combuſtion, or to a gradual exploſion of gun-powder.

This heat therefore ſhould be managed with ſome addreſs, as a great quantity of it would calcine or evaporate too much of the materials, and leave the remainder a leſs profitable maſs; as happens, I am informed, to ſome parts of thoſe heaps of manure, which are uſed in the manufactory of white lead; while on the contrary, when the heat is too ſmall, as in ſevere froſt, theſe proceſſes of decompoſition will not commence, or may be ſtopped in their progreſs. In the former caſe, where the heat is too great, it may be checked by covering the whole manure-heap with ſoil and turf, and thus preventing the acceſs of air. And when the heat is too ſmall, as in old hot beds, it may be renewed or promoted by turning the heap over with the ſpade, and thus confining a new quantity of air in its interſtices. On theſe accounts it appears, that in the vernal and autumnal months theſe proceſſes muſt ſucceed better than in the winter or the ſummer ones.

4. Toward the end of the putrefactive proceſs the materials ſhould be repeatedly turned over with the ſpade, not only for the purpoſe of ſimply expoſing their interior parts to the atmoſphere, but alſo of in-

cluding air in the interftices; as the union of carbon with oxygen, and probably of azote with hydrogen, feems thus to be occafioned; by which the three laft of thefe elements may change from a gaffeous ftate into a fluid one, and thus become abforbed by vegetable roots.

Laftly, I conclude that in general the manure heap before ftables, or in the fold-yard, fhould be placed on a gently rifing eminence, with a bafon beneath it, that the fuperfluous water, which would otherwife prevent the fermentation of the ftraw, may drain off and be there received; and that into this bafon, as often as a fluid appears in it, fome earth, or weeds, or leaves, or faw-duft, or other vegetable or animal recrements fhould be thrown; the fermentation and putrefaction of which will be thus forwarded, and the carbonic draining from the manure-heap will not be loft.

5. The admixture of lime with this carbonic foil is found by daily experience to produce the moft fertile compofitions for the growth of vegetables, and for the production of nitre. The great ufe of nitrous acid in vegetation has long been acknowledged, and that of hyper-oxygenated marine acid appears probable from recent experiments; and would feem to be occafioned by the more loofe adhefion of the oxygen in thofe acids to their refpective bafes; which may therefore in its fluid ftate be more readily abforbed by vegetable roots. One ufe therefore of the admixture of lime in fuch a compoft of foil and manure is to arreft the nitrous acid, as it is formed, and by making a calcareous nitre, prevent its exhalation, or its eafy elutriation from the other materials.

6. A principal circumftance for the quicker and more perfect decompofition of vegetable recrements is a due quantity of animal matter, and their being properly mixed together; as appears from the early experiments of fir John Pringle and Macbride, and by daily experience. There is neverthelefs great neglect in this refpect in all thofe farm-yards, where the fwine have their food in fixed ftone-troughs,

troughs, from which the refuſe is occaſionally waſhed or ſwept. Whereas if wooden moveable ſwine-troughs were always placed on the ſummit of the heaps of dry ſtraw, the quantity of their ſwill, conſiſting of broth, whey, and other vegetable and animal matter, which theſe animals waſte in their contention for it, would generate early putrefactive proceſſes; beſides their mixing the ſubſtances well together with their feet, and adding to it their urine and ordure.

Beſides this inattention to the manure-heap in many houſes the waſhings of boilers, and milk-pans, and diſhes, as well as the ſoap-ſuds, which are all of them manures of the moſt productive kind, are thrown into the common ſewer, inſtead of being derived or carried to the garden or the ſtraw-yard.

7. Another inattention to the production of manures concerns the heaps of common weeds, and of dock-roots, and of cabbage-ſtalks, and the roots of twitch-graſs; which improvident farmers and gardeners frequently throw into the high roads, or conſume with fire; and which if laid on heaps, and occaſionally turned over, and covered with ſoil, will quickly die, and paſs into ſpeedy fermentation from the ſugar and mucilage, which they contain; and if to theſe a portion of lime be added, I am informed by one who made the experiment, that the whole was decompoſed in a ſhort time, and manure of the beſt kind was the product.

The ſame ſhould be practiſed with the leaves which fall in autumn on graſs land, eſpecially from thoſe orchards, or hedges, or from gooſeberry-trees, which have been infeſted with caterpillars; ſince I am told the eggs of a future race of theſe inſects are frequently depoſited on the leaves, and hatched on or beneath the ſoil in the enſuing ſpring. Theſe therefore ſhould be removed from the roots of ſuch trees, and converted into manure by the proceſs above mentioned.

Along with the weeds and leaves above mentioned I ſhould ſtrongly recommend to the induſtrious agricultor to collect the water-plants which

which grow in great abundance in lakes and rivers, for the purpofe of manure; which at prefent are employed to no advantage. Thefe might be moved twice a year, as it is probable that thefe vegetables in their younger ftate, as the typha, or cat's-tail; the butomus, or flowering-rufh; nymphæa and alifma, as well as many other aquatic plants, would give better manure, or fooner become fufficiently decompofed, during their more faccharine and mucilaginous ftate, than when they have acquired more fibrous leaves, and more woody ftems.

By thus expofing the roots and tops of weeds to fermentation, their feeds would alfo be deftroyed as well as the vegetative power of their roots; and on this account the hay-feeds collected from ftacks, which have fermented too violently, fo as to become black by this flow combuftion, are frequently fo much injured as not to vegetate, to the great difappointment of the fower, a circumftance which alfo fometimes occurs in ftacks of wheat, as mentioned in Sect. XVI. 7. 1.

8. Laftly, peat, fo well underftood and fo ftrongly recommended by Lord Dundonald, is too much neglected in agriculture. The peat or turf, which conftitutes the folid parts of moraffes, as it confifts of vegetable fibres in different ftates of decompofition, may be laid on clayey or fandy foils with the greateft advantage; and ought to be confidered as an ineftimable treafure to the farms in its vicinity. Or it may previoufly be laid on heaps, and thus mixed with air and drained from water for further decompofition, with or without the addition of lime.

XII. APPLICATION OF MANURES.

Two queftions of importance here prefent themfelves. As the fpontaneous or chemical changes of manure-heaps in farm-yards gradually progrede from the faccharine and mucilaginous commence-

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ment through a great variety of other fermentations; which can only be named from the principal material, which each of them produces, as carbonic acid, alcohol, vinegar, volatile alkali, hydrogen, nitrous acid, and finally carbonic earth. At what era or ſtage of this decompoſition of vegetable and animal ſubſtances can they be moſt advantageouſly applied to the purpoſes of agriculture? and ſecondly, at what time of the year?

1. In reſpect to the era of the progreſs of the decompoſition in manure-heaps, in which they may be moſt advantageouſly applied in agriculture, the particular purpoſe of that application muſt be attended to. Where they are deſigned to be ſpread on the ſurface of graſs lands, as a top-dreſſing, the accumulations of vegetable and animal recrements ſhould be permitted to go through the various ſpontaneous proceſſes of decompoſition, which begin with the ſaccharine and mucilaginous ſtate, and end with the production of carbonic earth, with many kinds of intermediate fermentations, if they may be ſo called, which accompany or ſucceed each other, and which I believe to be more in number than have had names applied to them.

But that leſs of the fertilizing materials, whether of ſoluble ſolids, or of fluids, or of gaſſes, may be loſt in theſe ſeries of fermentations; it is a very advantageous management to cover them with ſoil, when the firſt fermentation is advanced, as is known by the production of conſiderable heat; or when the putrefactive one has commenced, which is known by the ſmell of volatile alkali, or of hydrogen. By this method the too great rapidity of theſe fermentations is checked, and the fluid part of the manure is retained by the addition of the ſoil below, and the gaſſeous part by that above; and if to this be afterwards added a proportion of lime, which by uniting with the nitrous acid may retain it from exhalation or from alluviation, every thing is preſerved that art can accompliſh.

Where manure-heaps are to be ploughed into clayey ſoils, which are liable to become too ſolid and impenetrable to the root-fibres of

ſeeds,

feeds, as of wheat; or where knobby or bulbous roots are to be inferted to produce other knobs or bulbs beneath the foil, as potatoes; it is probably more advantageous to bury the manure in a lefs decompofed ftate, while fome of the ftraw retains its form; as fuch parts by their flower decompofition will longer prevent the fuper-incumbent foil from becoming too folid; and though they will in this fituation require fome time before they will be perfectly decompofed, and reduced to the black carbonic earth; yet they will in the end totally decay, and give the fame quantity of nutriment to the roots, though it may be more gradually applied.

2. In refpect to the time of year thofe manures, which are to be ploughed or dug into the ground, fhould be ufed immediately before fowing the feeds or fetting the roots, which they are defigned to nurture; becaufe the atmofpheric air, which is buried along with the manure in the interftices of the earth, and which for many weeks, or even months, renders the foil loofe, and eafily impreffed by the foot on walking on it, gradually evolves by its union with carbon a genial heat very friendly to vegetation in this climate, as well as the immediate production of much fluid carbonic acid, and probably of a fluid mixture of nitrogen with hydrogen, which are believed to fupply much nutriment to plants.

But thofe manures, which are defigned to be fpread on the furface of grafs-land, which is called the top-dreffing, are beft applied, I fufpect, in the early fpring; and fhould be difperfed over the foil almoft in a ftate of powder, or in lumps of very loofe cohefion; as at this time the vernal fhowers wafh them into the foil; and they are applied to the roots of the grafs, before their effential parts are diminifhed by winter rains or by fummer exhalation. There are fome in Derbyfhire, who fpread manure even on the meadows, which are annually overflowed by the Trent or Derwent, at the end of fummer, or as foon as the grafs is mowed and removed; which appears to be an improvident management, fince the aftermath, or autumnal grafs, is thus rendered unpalatable to the cattle; and the winter rains, or the vernal floods, which generally occur with the return of the south-weſt winds, after the ſeaſon of froſt ceaſes, muſt waſh away a great part of it.

In reſpect to the moſt economical manner of uſing manures in agriculture Mr. Parkinſon aſſerts, that one great advantage of the drill-huſbandry conſiſts in putting the manure into drills, which he directs to be made at two feet diſtance from each other. He ſows wheat, beans, peas, cabbages, on this manure, and affirms, that four loads of manure on an acre in this kind of huſbandry is equal to ſixteen loads in the uſual way of ſpreading it over the whole of the field. Experienced Farmer, Vol. I. p. 32.

3. A third queſtion here preſents itſelf, if the recrements of vegetable and animal bodies buried a few inches beneath the ſoil undergo the ſame decompoſition, as when laid on heaps in farm-yards. And though this is accompliſhed more ſlowly, yet it is attended with leſs loſs of carbonic acid, and of volatile alkali, and of hyrogen, and of the fluid matter of heat; all which are emitted in great quantity during the rapid fermentations of large heaps of manure, and are waſted in the atmoſphere, or on unprolific ground; would it not in general be more economical to bury ſuch vegetable and animal matters beneath the ſoil without a previous fermentation and putrefaction?

In anſwer to this it muſt be obſerved, that in ſome caſes the uſe of recent vegetables ploughed into the earth is found of advantage, as in ſandy ſoils buck-wheat, or vetches, are ſown, and the crop ploughed in, before it ripens its ſeeds. In this circumſtance the recent crop is buried in its ſaccharine and mucilaginous ſtate, which muſt undergo indeed a ſlower fermentation, without being mixed with animal ſubſtances, but no part of the organic matter, nor of the fluid heat, is loſt to the purpoſes of new organization.

So in the cultivation of clayey lands, whoſe tenacity is too great;

or

or where knobby roots, as potatoes, are to be inferted for the production of other knobby roots beneath the foil; long muck, as it is called, or fuch which is only fo far decompofed as to diffolve the mucilage or more tender veffels or membranes, but in which the form of the fibrous or ligneous parts of the ftraw remains, is recommended above; and may in thefe fituations perhaps be ploughed into the ground even in their moft early ftate, when rejected from the ftable or cowhoufe, before the commencement of their fpontaneous diffolution.

So alfo in gardens, which are already fertile, and do not want the immediate affiftance of mature manure, it may be more economical to bury the weeds, as the ground is dug, than to convey them to a manure-heap, and replace them after a twelvemonth's decompofition.

But where a luxuriant crop is immediately wanted, a manure-heap towards the end of the putrefactive procefs by being recently interred in the foil, which is immediately to be fown or planted, has this great advantage; that the carbonic acid is prefently formed by the mixture of atmofpheric air with the carbon of the manure; which exifts therefore in its fluid, not its gaffeous ftate, and is thence more readily abforbed. Secondly, ammoniac is produced, and nitre, and hydrogen probably is mixed with nitrogen; and thefe alfo, I fuppofe, exift at firft in their fluid, not in their gaffeous ftate. And thirdly, from thefe combinations a genial degree of heat is evolved, which fo much affifts the vernal growth of vegetation.

And where manure is to be ufed as a top-dreffing, it is neceffary, that it fhould be in a ftate of powder, or in fmall lumps of loofe cohefion, as mentioned above; that it may be eafily wafhed by rains to the roots of the grafs, or that the young ftems of grafs may readily fhoot themfelves through it; whence mature heaps of manure are for this purpofe neceffary; and on this account any adhefive ma-

nure,

nure, as cow-dung itſelf, ſhould be weekly gathered from graſs-ground, where cattle are nouriſhed, and laid on heaps with ſoil, or ſtraw, or weeds, to ferment or putrefy; till it becomes leſs tenacious, and can be profitably replaced in the enſuing ſpring.

Finally, I ſuſpect the moſt economical method of diſpoſing of the ſtraw and dung from the farm-yard would be, as ſoon as a dark coloured water drains from the heap, by which much loſs is ſuſtained, to carry the refuſe of the ſtable and cow-houſe, as frequently as convenient, to the ground, where it is deſigned to be employed; and there to mix it with earth in heaps of proper ſize, and to cover them likewiſe with ſoil; and by theſe means I ſuppoſe the whole proceſs of decompoſition may be carried on with very little loſs; and by the addition of a greater or leſs quantity of ſoil that the era of complete or moſt profitable decompoſition of the compoſt may be managed, ſo as to coincide nearly with the time it may be wanted.

4. Fourthly, it may be aſked, what kinds of manure contribute moſt to the luxuriant growth of vegetables? In anſwer to this it may be ſaid, that as plants are inferior animals, and are furniſhed with abſorbent veſſels in their roots correſpondent to the lacteals in the ſtomach; that the ſame organic matters, which by their quick ſolution in the ſtomach ſupply the nutritive chyle to animals, will by their ſlow ſolution in or near the ſurface of the earth ſupply the nutritive ſap-juice to vegetables. Hence all kinds of animal and vegetable ſubſtances, which will undergo a digeſtive proceſs, or ſpontaneous ſolution, as the fleſh, fat, ſkin, and bones, of animals; with their ſecretions of bile, ſaliva, mucus; and their excretions of urine, and ordure; and alſo the fruit, meal, oil, leaves, wood, of vegetables, when properly decompoſed on or beneath the ſoil, ſupply the moſt nutritive food to plants.

Secondly, the chyle of all animals is ſimilar to the ſap-juice of all vegetables in this circumſtance, that they both contain mucilage and fugar, and feem only to differ in this refpect, that the chyle of animals alfo contains oil, which being mixed with the mucilage gives it its whitenefs like milk. Hence thofe matters muft fupply nutriment moft expeditioufly to vegetables, which contain mucilage and fugar, or produce them with the leaft decompofition, as the jellies from the fhavings of horns, from hair, woollen rags, and the faccharine matter of fweet fruits, roots, kernels, feeds ; and in the fame manner thefe things with the addition of oil are moft expeditioufly nutritive to animals.

Thirdly, fuch materials as contain in folution thofe fimple fubftances, which conftitute a great part of vegetable bodies, as carbon, which is found in moft earths ; and oxygen, hydrogen, and nitrogen, which are found in water and in air ; and from hence we may conclude, that whatever material has conftituted a part of living organic bodies, may again conftitute a part of them ; and that with more expedition, if they can be ufed without being decompofed into their primary elements.

Mr. Bewley, the Norfolk philofopher, faid to a friend, who was riding by his fide, that when he wanted a whip, he habitually looked for a dead ftick in the hedge, unwilling to pluck off a leafy branch, and deftroy fo many living buds. He might have added, that to burn a hair or a ftraw unneceffarily diminifhes the fum of matter fit for quick nutrition by decompofing it nearly into its elements, and fhould therefore give fome compunctions to a mind of univerfal fympathy.

It would feem therefore, that long roots fixed into the earth, and leaves innumerable waving in the air, were neceffary for the decompofition and new combinations of water and air, and the converfion of them into faccharine and mucilaginous matter ; which would have been not only cumbrous but totally incompatible with the locomotions of animal bodies ; for how could a man or quadruped have

have carried on his head or back a foreſt of leaves, or have trailed after him long branching lacteals terminating on the ſurface of the earth? Animals therefore ſubſiſt on vegetables; that is, they take the matter ſo far prepared, and poſſeſs organs to prepare it further for the purpoſes of greater ſenſibility, and of higher animation.

SECT. XI.

OF DRAINING AND WATERING LANDS.

I. 1. *Moraſſes are in high or low ſituations.* 2. *Springs riſe from the ſummits of mountains, paſs between the ſtrata.* 3. *Strata of the earth about Derby, and at Lichfield, and the ſprings.* 4. *Plains formed in vallies.* 5. *Wall-ſprings intercepted by ditches, ſunk perpendicular to the ſides of the hills.* 6. *By boring holes at the bottom of ſuch ditches.* 7. *Uſe of ditches, where the wall-ſprings cannot be intercepted.* 8. *Holes through clay into a ſand-ſtone beneath.* 9. *Deep ſprings riſe higheſt, when bored into.* 10. *Many ſprings may be raiſed higher than their ſources.* 11. *Enlarging the bottom of wells increaſes the water in them.* 12. *Springs diſcovered on one ſide only of ſome mountains. Diſcovered by evening miſts. By morning rime. By aquatic plants. Warm ſprings.* II. 1. *Draining moraſſes, where there is no fall.* 2. *In the craters of ancient volcanoes.* 3. *In countries of marble, granite, or quartz.* 4. *Fens below the level of the ſea. Should be ſurrounded with dikes.* 5. *Uſes of aquatic plants.* III. 1. *Of flooding lands.* 2. *Ice preſerves the graſs beneath. The French bored holes in the ice.* 3. *Advantages of flooding recapitulated. It deſtroys ruſhes. Saves manure.* 4. *Cautions to be obſerved. Flooding not injurious to health. Vicinity of running water wholeſome.* 5. *Flooding lands might be performed to a great extent. By rivers, ſprings, land-floods, and machinery. Hiero's fountain. Horizontal wind-mill, and centrifugal pump.*

I. 1. THE great quantity of water required for healthy vegetation is treated of in Sect. X. 3. 1. But as all extremes are injurious, too much water becomes pernicious to all except aquatic plants. Whence the neceſſity of draining thoſe lands, which too much abound with moiſture; the art of which is better underſtood, ſince the knowledge

 of

of geology has been ſtudied, and in ſome meaſure diffuſed amongſt the people.

Lands in reſpect to the method of draining them may be divided into two ſituations; thoſe which lie ſo high, that the water can deſcend from them, if it be properly collected and conducted; and thoſe which lie ſo low as to command no fall, ſome of which are even below the level of the ſea.

2. In regard to the former it generally happens, that the waters from the ſprings beneath the ſoil have not a free paſſage to the rivers in their vicinity; the nature of ſprings ſhould therefore be previouſly underſtood. Many modern philoſophers have endeavoured to ſhew, that all the continents and iſlands of the world, as well as the hills, which emboſs their ſurfaces, have been raiſed out of the primeval ocean by ſubterraneous fires. This appears from the quantity of ſea-ſhells, which form innumerable mountains; and from the fiſſures in the rocks, of which they conſiſt; the quantity of volcanic productions all over the world; and the numerous remains of craters of volcanoes in mountainous countries.

Hence the ſtrata, which compoſe the ſides of mountains, lie ſlanting downwards; and one or two or more of the external ſtrata not reaching to the ſummit, when the mountain was raiſed up, the ſecond or third ſtratum, or a more inferior one, is there expoſed to day. This may be well repreſented by forcibly thruſting a very blunt inſtrument through ſome folds of paper, a bur will be raiſed with the lowermoſt leaf ſtanding higheſt in the center of it. Or if at the original elevation of an extenſive mountain the loweſt ſtratum ſhould not at firſt ſtand higher in the center of the ſummit, it would in time become ſo by ſome of the upper ſtrata of the mountain being gradually waſhed away by rains into the valleys or rivers. On this uppermoſt ſtratum, which is colder, as it is more elevated, the dews are condenſed in large quantities; and ſliding down paſs under the firſt, or ſecond, or third ſtratum, which compoſe the ſides of the hill;

hill; and either form a moraſs below, or a weeping rock by oozing out in numerous places; or many of theſe leſs currents meeting together burſt out in a more copious rill.

The immediate cauſe of ſprings conſiſts therefore in the condenſation of the atmoſpheric moiſture, during the night principally, by the greater coldneſs of the ſummits of hills, which is explained in detail in the Botanic Garden, Vol. I. additional note 26. The water thus condenſed on the ſummits of hills deſcends between the ſtrata of the incumbent ſoil, ſometimes for many miles together; but generally from the neareſt eminences into the adjoining vallies.

3. Thus there is a ſtratum of marl, which I have obſerved on the ſurface of the lands about Derby, which extends many miles in moſt directions. This ſtratum of marl is of various thickneſs from 10 to 150 feet, and beneath it lies a ſtratum of ſand, which is alſo of various thickneſs from a few inches to ſix or eight feet, and of various degrees of induration; and beneath this lies another ſtratum of marl to an unknown depth. On the top of Radborne common, about five miles north-weſt from Derby, the ſandy ſtratum is quite looſe, and riſes above the ſtratum of marl, which is deficient at the ſummit of the hill. Three or four ſtrong ſprings of water burſt out on the ſides of this hill, which thus originate from the moiſture of the atmoſphere condenſed on the cold ſummit, and paſſing through the ſandy ſtratum between the two ſtrata of marl.

In the road to Duffield, about two miles north of Derby, the ſand-ſtratum is cemented into ſtone, as well as in ſome ſituations near Radborne-common above mentioned. This ſtratum of ſand-ſtone is ſome feet in thickneſs, and lies four or five yards deep, beneath the upper ſtratum of marl, dividing it from the lower one. At Normanton, about two miles ſouth from Derby, the ſand-ſtratum conſiſts of a looſe ſand, ſo white and pure, that I imagine it might be uſed in the manufacture of flint-glaſs, and lies about twelve feet deep, beneath the upper ſtratum of marl, dividing it from the under one. In the town of Derby on boring with defign to fink a well, after having paffed about thirteen yards through marl, fome fand was brought up by the auger, and water followed, as related in the Philof. Tranfact. Vol. LXXV.

The dews therefore, which are perpetually condenfing on the fummits of thefe hills, defcend beneath the upper and under ftrata of marl, through the thin ftratum of fand, which divides them, and form St. Alkmund's well, and many other fprings in the vicinity of Derby; and probably all thofe which fupply the wells within the town.

But there is a fituation, where the manner of the production of fprings is moft agreeably vifible; it is about a mile from the city of Lichfield, near the cold bath erected by fir John Floyer, in a beautiful piece of ground, which was formerly Dr. Darwin's botanic garden.

In this place a grotto about fix yards wide and ten long has been excavated on the fide of a hill confifting of filiceous fand-ftone with this peculiar circumftance; that the upper ftratum of the fand-rock, which is there about five feet thick, is divided from the lower ftratum of it by a fheet of clay not more than three or four inches in thicknefs; on the upper furface of this fheet of clay, between the lips of thefe rocks, a perpetual dribbling of water oozes quite round the grotto, like a fhower from a weeping rock. Such fheets of water having been often obferved to flide between the ftrata of the earth almoft horizontally, like the horizontal joints of a ftone-wall, have, I fuppofe, given the name of wall-fprings to them, to diftinguifh them from pipe-fprings, or fuch as burft out in a fingle rill.

Thus this thin fheet of clay prevents the water from finking into the lower ftratum of fand-ftone; and produces other copious fprings, which are collected at about half a mile's diftance, and conveyed by leaden pipes to the cathedral clofe of Lichfield, which is thus fupplied with water of uncommon purity, which contains no calcare-

ous

ous earth, owing to its paffing through filiceous fand over a ftratum of clay, and which would be a treafure to the paper-mill or the bleach-yard.

4. One other circumftance in the prefent conformation of the earth is neceffary to be mentioned; which is, that at the time when the mountains were raifed all over the world by deep volcanoes, or by central fires, fome parts of the fummits of many of them, and of their fteeper fides, rolled down again into the new formed vallies. And fecondly, that fince that remote time the recrements of vegetable and animal bodies have continually been wafhed down from the eminences by fhowers, and have contributed gradually to accumulate in the vallies, and to form the plains, which exift on the fides of rivers. This appears from the tin ores found in the vallies in Cornwall in loofe pieces fimilar to thofe in the proximate mountains; and from the black carbonic foil, or morafs-turf, found in moft vallies.

5. From thefe clear ideas of the ftrata of the earth, and of the ftreams of water, which flide between them, and form what are termed wall-fprings, it is eafy to conceive, that the beft method of preventing the vallies at the bottom of hills from being too moift muft be by cutting a long horizontal ditch into the fide of the mountain to intercept the water, juft before the level land of the valley commences; and thus to carry away the water before it comes upon the plain beneath.

For this purpofe at the foot of the hill where the plain, which is too moift, commences, fome auger-holes fhould be bored to find the depth of the fprings, that is to find the thicknefs of the upper ftratum of the foil. If this be only four or fix feet, an horizontal ditch fhould be cut along the bottom of the mountain to intercept the water; which muft then be carried away by one or more other ditches opening into this, and conducting the water fo collected into the neighbouring rivulet.

As the ftrata, between which the water defcends in forming thefe fprings, ſprings, have generally the ſame inclination as the ſurface of the hill, or nearly ſo; it follows, that the holes ſhould be bored, and the ditch cut, not vertically downwards, as is the common practice, but perpendicular to the ſurface of the mountain; as by that means the ſecond ſtratum will ſooner be arrived at; as ſhewn in Plate V. at the end of this Section.

6. But if on cutting a ditch five or ſix feet along the bottom of the hill perpendicular to the riſing plain, which forms the ſide of it, the upper ſtratum be not cut through; and in conſequence no water oozes into the bottom of the ditch; it is then proper to bore other holes at the bottom of this ditch ſome yards deeper, or till water riſes up through them into the ditch, if it can be ſo diſcovered. Where this ſucceeds, many holes ſhould be bored, and the water received into the ditches, and conducted into the adjacent river; for the water will then riſe into the bottom of this ditch ſix feet below the wet ſurface of the valley, and thus flow away, rather than riſe up from the lower wall-ſprings, or apertures of the ſtratum, through the incumbent ſoil to the ſurface of the valley, which is ſo many feet higher. This well underſtood is the great ſecret for draining thoſe grounds, where the ſprings can not be cut into ſimply by a ditch.

This method has been ſome years practiſed with ſucceſs by Mr. Elkington, but was previouſly uſed and explained by Mr. Anderſon, as he aſſerts in his introduction to Vol. III. of his Eſſays on Agriculture, who ſunk a hole into the earth at the bottom of a ditch in the year 1764, and the water roſe ſix feet above the ſurface of the ground, and has continued to flow with leſs violence ever ſince that time.

It ſhould here be noticed, that where the water riſes with great force through holes thus bored into a deep ſtratum, it is liable to bring up along with it much ſand, ſo as ſometimes to obſtruct its paſſage; which ſand in this caſe muſt frequently be removed for a few days by the reapplication of the auger. Of this a remarkable inſtance

ſtance is publiſhed in a late volume of the Phil. Tranſ. by Mr. Wulliamy, who ſunk a well 236 feet deep and four feet wide; and, on then boring a few feet lower with a five-inch borer, ſo much ſand aroſe with a violent ſtream of water, as to fill up the whole well; which was repeatedly cleared away by buckets in its fluid ſtate, and at laſt the water ran over the ſurface to the amount of forty-ſix gallons in a minute.

The manner of making theſe ditches narrower, as they deſcend, by ſpades of an adapted breadth; and of making the loweſt part narrower than any other part, ſo that the ſhoulders or edges of it may ſupport ſtones, or faggots, to cover the whole at a ſmall expence without obſtructing the currents of water, are obvious to the workmen. In many ſituations hollow bricks, or ridge-tiles, or old pieces of plaſter-floors, may be worth the aditional expence of providing them.

7. There may nevertheleſs be found ſituations, where the firſt ſtratum of earth may be too thick to be eaſily penetrated; or where the water, condenſed from the atmoſphere on the ſummits of the hills, may ſlide between the ſecond and third, or between the third and fourth ſtrata, which form the ſides of thoſe hills, owing to a deficiency of ſo many of the ſtrata at the ſummits of them; and hence that it may lie too deep to be eaſily arreſted by a ditch, or by boring; and yet by its being dammed up by the materials, which form the level plain of the valley, may riſe up through thoſe materials to the ſurface, and form boggy or moraſſy ground.

In theſe ſituations the common unſkilful method of draining may be uſefully employed; which conſiſts in cutting many ditches four or ſix feet deep acroſs the bog or moraſs; and covering them, ſo that the water may have no obſtruction in paſſing along them; which may thus, as it riſes from below, be in part collected and conveyed away; though leſs advantageouſly than where the ſprings can be intercepted.

Another

Another method of draining moiſt meadows has been by making or opening drains almoſt annually by a large plough with two converging coulters, and other adapted parts, for the purpoſe of cutting both the ſides of a ditch at the ſame time, and turning out the intervening turf and ſoil. Theſe large ploughs have been kept in ſome pariſhes, and drawn over moiſt commons by twelve or twenty horſes, to form parallel ditches.

Mr. Adam Scott has invented for the ſame purpoſe what he terms a mole-plough, which conſiſts of a coulter fifteen inches long, and two and a half wide, to cut the ſward; and behind this an horizontal cone of caſt iron twenty inches long, and two and a half diameter at the baſe, to the middle of which is fixed an upright bar two feet long, and three inches and a half broad, with a ſharp edge. As this caſt iron cone is drawn along ſix or eight inches beneath the turf in moiſt lands, either in the ſpring or autumn, in many parallel lines, the water for a conſiderable time is conveyed away, and no injury done to the ſurface; which thus ſeems to be an uſeful machine, and may be well managed, I am informed, by ſix or eight horſes. In very moiſt lands, or at very moiſt ſeaſons, if more horſes be uſed, their feet will not ſink ſo deep into the turf, as each horſe will draw leſs; or a contrivance of adding broader ſhoes of wood to the horſes like the ſnow-ſhoes of higher latitudes, might anſwer this purpoſe. See Tranſact. of Society of Arts, Vol. XV.

8. There are nevertheleſs ſome ſituations, where the water is conveyed beneath the firſt ſtratum on a thin bed of clay over a porus ſand-ſtone beneath it; as in the grotto at Lichfield above deſcribed. In theſe ſituations by boring many auger-holes, or by ſinking wells, through the ſtratum of clay the water will penetrate the ſand-ſtone beneath it; and either paſs away by the poroſity of this kind of ſtone, or by the cracks or joints which are always found in it; of which the horizontal joints were formed at the time of the production or accumulation of the ſand beneath the ſea, which was then formed in horizontal

horizontal ſtrata ; but the vertical cracks were made at the time of its elevation by ſubterraneous fires. In theſe vertical fiſſures the ores of lead, ponderous earth, and calcareous ſpars, are found in the lime-ſtone rocks of Derbyſhire ; and thoſe of tin, and quartz, in the granite rocks of Cornwall.

9. The knowledge of this part of geology concerning the formation of ſprings may be employed for many uſeful purpoſes ; thus where the wall-ſprings, or water-conducting ſtrata, lie ſo deep as not to be acceſſible at a ſmall expence ; they generally exiſt between the ſecond and third, or between the third and fourth ſtrata ; which riſe into day higher on the ſummits of the adjacent mountains than the firſt ſtratum ; and hence, when they are bored into, the water will riſe higher, than when it is found beneath the firſt ſtratum only ; which generally becomes deficient on lower parts of the adjacent eminences of the country.

Thus where water, deſcending in high columns between the ſtrata of mountains, is dammed up below by the materials, which fill up the vallies ; if a hole be bored in the valley deep through the incumbent ſoil and ſtrata, it frequently riſes much above the ſource of the new aperture, and ſometimes above the ſurface of the ground. In ſinking the king's well at Sheerneſs the water roſe 300 feet above its ſource in the well, as related in Philoſ. Tranſact. Vol. LXXIV. And at Hartford in Connecticut there is a well, which was dug ſeventy feet before water was found ; and then on boring an auger hole through a rock the water roſe ſo faſt, as to make it difficult to keep it dry by pumps, till the hole could be blown larger by gunpowder ; which was no ſooner accompliſhed, than it filled, and run over, and has been a brook for near a century. Travels through America, Lond. 1789. Lane.

In the town of Richmond in Surry, and at Inſlip near Preſton, in Lancaſhire, I am informed, that it is uſual to bore for water to a certain depth ; and that when it is found in both thoſe places, it riſes fo high as to flow over the furface. And there is reafon to conclude, that if fimilar experiments were made in many other places, fuch artificial fprings might be produced at fmall expence, both for the common purpofes of life, and for the great improvement of lands by watering them.

10. Another deduction, which may be made from this knowledge of geology, is, that many fprings of water, which lie too low for ferving a houfe, or ftreet, or town, or for watering higher grounds for the purpofes of agriculture or gardening, may in many fituations be dammed up many feet with little or no lofs. Thus when the new bridge was building at Dublin, Mr. G. Semple found a fpring in the bed of the river, where he meant to lay the foundation of a pier; which by fixing iron pipes into it he raifed many feet; and in boring a hole near the Derwent in Derby about fifteen yards deep, the water rofe above the furface of the ground, and has continued to flow now for above twelve years in rather an increafing quantity. From having obferved a valley north-weft of St. Alkmund's well near Derby, at the head of which that fpring of water once probably exifted, and by its current formed the valley, (which current in after times found its way out in its prefent lower fituation), I fufpect, that St. Alkmond's well might by building round it be raifed high enough to fupply many ftreets in Derby with fpring water, which are now only fupplied with river water.

11. A third deduction from the knowledge of this geology concerning the production of fprings teaches, that by enlarging the bottom of a well, where the water oozes from between the furrounding ftrata in too fcanty a fupply, a proportionally greater quantity of water may be procured. The hole near the river Derwent in Derby above mentioned, is about an inch and a half in diameter, and was bored about fifteen yards deep through the uppermoft ftratum of marl into the fand beneath it, and fupplies Dr. Darwin's houfe with two or three hogfheads of water a day. And Mr. Strutt near St. Peter's

ter's Bridge has ſunk a well for the uſe of his ſteam-engine about 200 yards from the former, which paſſes through the ſame upper ſtratum of marl, and is three feet in diameter at the bottom, and ſupplies, when required, a hundred hogſheads in a day.

12. The knowledge of this part of geology leads to another uſeful purpoſe, the diſcovery of ſprings; concerning which ſome have pretended to poſſeſs ſecret or myſtical intelligence both in England and in France. When the eminences of a country were raiſed out of the primeval ocean by ſubterraneous fires, ſome of them were raiſed nearly equally on all ſides, like the limeſtone mountain at Breedon in Leiceſterſhire; in which the central ſtratum may be ſeen to ſtand nearly erect or vertical, and thoſe on all ſides at conſiderable inclination. Other mountains were abruptly broken off on one ſide only from the adjoining earth, like thoſe which form the high torr at Matlock; which riſe with one of their ſides perpendicular as a wall by the Derwent ſide; ſo that the ſtrata of the former of theſe mountains may be repreſented, as before mentioned, by the bur, which would be made on ſome folds of paper, if a very hard blunt inſtrument was thruſt through them; and the latter by raiſing up one edge of ſuch folds of paper, ſo as to incline the whole of it at ſome angle with the horizon.

As the ſprings conſiſt of the water, which ſlides between theſe inclined ſtrata; it is evident, that in ſome eminences of ground they are only to be met with on one ſide of the mountain; and in other eminences of ground on all ſides of it. In ſearching for ſprings therefore attention ſhould be given to the inclination of the ſtrata of that part of the country, which may be often ſeen in marl-pits, gravel-pits, or in hollow lanes. But they may in general be found above any moiſt or moraſſy plain or valley; the moiſture of which ſhews, that ſprings exiſt in the ſtrata on that ſide of the mountain.

A ſecond obſervation for the purpoſe of detecting ſprings may be made on miſty evenings; as thoſe parts of the ground, where the mist commences, are moister than those in their vicinity on the same level; and in consequence may generally, if they are not hollow basons, possess springs nearer the surface; for these moister parts of the ground, having evaporated more during the day, are become colder on their surfaces than the drier ground in their vicinity; and in misty evenings, which are at the same time calm, the stationary air over these moist parts of the ground is also more loaded with the evaporated moisture; and on both these accounts these moister situations are liable to shew a condensation of aerial vapour sooner than other places on the same level.

As mountains are colder in proportion to their height, which is explained in Botanic Garden, Vol. I. additional note 26, the evening mist sometimes commences sooner on them than in the valleys; but is seen earlier in these situations over the moister places, if they are on the same level with the drier ones, exactly as on the plains or valleys; and may therefore indicate the existence of springs, unless these moister places consist of hollow basons containing water, which if not attended to may in all situations deceive the observer.

Another observation for detecting springs may be made in rimy mornings; for as moist earth is a better conductor of heat than dry earth, the rime will sooner melt on those parts of the soil, which are kept moist by springs under it than on other parts; as the common heat of the earth, which is 48 in this country, will sooner be conducted upwards in moist places to dissolve the rime on the surface. On this account the rime is frequently seen on frosty mornings, when the heat of the air is not much above 32, to lie an hour longer on dry cakes of cow-dung, or on bridges, or planks of wood, than on the common moist ground; as the latter much better conducts the common heat of the earth to the incumbent rime, which is in contact with it.

But as the heat of the common springs in this country is 48, where they exist, the rime is sooner dissolved, than on the stagnant moisture

ture of bogs or moraſſes. And as the ſprings about Buxton and Matlock, and at Bath and Briſtol, are ſo much warmer than common ſprings; it is highly probable, that where theſe waters approach the ſurface of the ſoil, they muſt much ſooner diſſolve the rime on froſty mornings; which may probably be obſerved in ſituations much higher than their preſent apparent ſources; as they ſlide down between the interior ſtrata of thoſe hills, beneath the ſummit of which they are condenſed from the ſteam of water boiling at great depths in the earth; which riſes up through thoſe perpendicular clefts of the rocks, which were formed at their original elevation, as explained in Botanic Garden, Vol. II. note on fucus; and in Pilkington's View of Derbyſhire, V. I. p. 256.

In the winter months the riſe of ſprings may be detected in moiſt ditches by the preſence of aquatic plants, as of water-creſs, water-parſnip, brook-lime; as in thoſe ditches, which become dry in the ſummer, theſe plants do not exiſt; and when thoſe ditches with ſprings in them are nearly dry, it may be diſcovered which way the current has formerly deſcended by the direction of the points of the leaves of the aquatic plants as certainly as by a level; an obſervation which I learnt from Mr. Brindley, the great canal-conductor of Staffordſhire.

Finally, theſe arts of detecting the ſituation of ſprings may be advantageous to the attentive agricultor both for the purpoſes of draining thoſe lands, which too much abound with water, and for the purpoſe of watering thoſe, which are too dry, and which lie beneath the level of the ſprings, or to which the water may be raiſed by wind-mills or water-engines to be explained hereafter.

II. 1. In reſpect to draining thoſe plains or moraſſes where no fall can be had, the water may in many ſituations be caught by cutting a long horizontal ditch into the adjoining mountain perpendicular to the inclined plane, which conſtitutes the ſide of the mountain, above the level of the moraſs, ſo as to intercept all the wall-ſprings; and

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may then be conveyed away in wooden troughs or hollow bricks above the ſurface; and if ſome water ſtill finds its way into the moraſs, this leſs quantity may be conducted to one extremity of the ground in open drains or covered ſoughs, and raiſed by an horizontal windmill and centrifugal pump, as deſcribed at the end of this Section; and thus the moraſs may be converted into ſoil of the moſt productive kind.

2. There may be other ſituations, as in the Peak of Derbyſhire, where pools of water, or moraſſes, are collected on the hollow ſummits of hills; which have been the craters of volcanoes in the primeval ages of the world, as Elden-hole near Caſtleton, which ſeems to have been the ſhaft of ſuch a volcano. In many of theſe baſons on the ſummits of hills there ſtill exiſt what are called "Swallows," or cavities; where the water ſinks into the earth, as it collects, to paſs to ſome diſtant valley, as Elden-hole above mentioned, and as in the channels of the rivers Hamps and Manifold, between Aſhbourn and Leek. In others, as at the ſummit of a ſteep promontory called Axedge, near Buxton, and about Broke-houſe, are unfathomed moraſſes, which are ſaid in ſome places not to bear a ſheep to paſs over them; and that on the more tenacious parts of them it is neceſſary for the adventurer to ſtep from taſſock to taſſock, or to carry a long pole horizontally in his hand, like thoſe who ſkaite upon ſuſpected ice, to prevent his ſinking over head, if he ſhould chance to ſink at all.

It is probable, that by ſinking a well, or boring a hole, where ſuch moraſſes or lakes now exiſt, into the obſtructed ſhaft of the ancient volcano, the water might be let off from thoſe eminent moraſſes at leſs expence, than by excavating a paſſage for it ſome miles in a country of marble.

3. It is poſſible there may be ſituations in high countries of marble, or granite, or quartz, where the difficulty and expence of excavating the ground may be too great, as above; in which a ſyphon might be contrived for the purpoſe of raiſing the water from a mo-

rafs or lake, and conveying it away. Such an inftrument might be conftructed of bored Riga deals; but as air is liable to collect in the fummit of a fyphon from the water, which paffes through it, it would be neceffary to fix at the fummit an air-veffel with an air-pump at the top of it; which might be moved by a very fmall horizontal windmill fail, to be defcribed at the end of this Section, or occafionally by the hand of a labourer for a few minutes perhaps once or twice a day.

4. The draining of thofe large plains, which lie beneath the level of the fea, is a fubject, which belongs to the public, rather than to the individual farmer; and is practifed near Linn on the river Cam by locks to keep out the tide, and by windmills to lift or forward the otherwife ftagnate water in the fen-dikes. Thefe windmills have vertical fails of the common kind, which move a vertical water-wheel, by which the water is raifed a foot or two; but it is probable even this might be done better by the horizontal fail and centrifugal pump to be defcribed at the end of this Section, as being a fimpler machine, and requiring no attention to turn it to the wind.

It might be a noble work, worthy the attention of a government, that wifhed to increafe the quantity of nutriment, and confequent population and happinefs of the country, to employ proper engineers with a number of labourers to environ with ditches every moraffy diftrict of whatever extent, which lies beneath the level of the tides, as the fens of Lincolnfhire and Cambridgefhire. Thefe ditches fhould be cut at the feet of the adjacent rifing grounds, or of eminences furrounded with fens, like iflands in a lake, fo as to intercept the wall-fprings and land-floods, and convey the water thus collected above the level of the morafs into the ocean.

But this, I fear, is an effort not to be expected in the prefent times, when the enclofure of forefts and large commons is prevented by the intereft of individuals, or by the difficulty of procuring expenfive acts of parliament for every minute diftrict, inftead of including them in

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a general act, so meritoriously contended for by sir John Sinclair, then President of the Agricultural Society.

5. Where finally the draining of marshy grounds can not be effected at a responsible expence, some plants may perhaps be cultivated with profit to the cultivator; as in some situations the festica fluitans, floating fescue, callitriche, star-grass; or in others the orchis for the purpose of making saloop by drying the peeled roots in an oven. This might be better worth notice, if the seed could be ripened in this climate for its easier propagation, which probably may be accomplished either by cutting away the new root, as is affirmed in the Amœnitates Academicæ; or by planting them in a garden-pot so as to confine the roots in respect to space, which is said in the same work to ripen the seeds of convallaria, lily of the valley; and lastly by cultivating a few on a hot-bed or in a green-house.

In other situations the menyanthes, bog-bean, would flourish abundantly, and might become a substitute for hops in the brewery, and be equally wholesome and palatable. It is indeed much to be lamented, that we have no grain similar to rice, that will grow in watery grounds in this cold climate, nor any esculent roots or foliage except the water-cress. There is reason to believe nevertheless, that the roots of nymphæa, water-lily, or of butomus, flowering-rush, may be esculent by simple boiling; or that a wholesome starch might be obtained from them; or lastly, that they might be fermentable into ardent spirit, like the roots of potatoes, or into vinegar.

The nymphæa nelumbo is much cultivated in China in their swampy grounds, and in their lakes. The seed is like an acorn, and of a taste more delicate than that of almonds. The roots are sliced and served with ice in summer at their tables; and are preserved in salt and vinegar for the winter. Embassy to China by sir G. Staunton, Vol. III. p. 214, 8vo. ed. The nymphæa alba of our country produces a root of three or four inches in diameter. See Sect. XVII. 2. 3; and though the seed is very small, and perhaps does not per-

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fectly ripen, I have obferved it to be agreeable to the palate both in its recent ftate, and when dry.

If thefe fhould not fucceed, other quick-growing plants might be cultivated for manures, as typha, cat's-tail, caltha, and others; which fhould be mowed twice a year, while they are young, and in confequence abound with faccharine and mucilaginous matter ready to pafs into fermentation.

III. 1. The advantages refulting from occafionally covering lands with water have long been experienced in warmer countries, as in Egypt, Italy, and many parts of China; and have of late years been introduced into our own more northern climates. The great importance of much water to the progrefs of vegetation has already been fpoken of in Section X. 3. And in the warm climates above mentioned, it is particularly ufeful in the cultivation of rice for the purpofe perhaps of fimply moiftening the ground.

But the advantages of flooding meadow-lands in this country may be divided principally into three kinds, one of which confifts in fimply moiftening them, which feems to be the principal ufe of watering lands in warm countries, where the water is derived to them almoft every evening from refervoirs above them, or from waterwheels worked by affes, and which is fometimes done in the gardens of this country by watering pans and human labour.

The fecond and greater advantage of flooding lands in this climate confifts in deriving much water over them from rivers or from ftrong fprings, and by thus fupplying them with the muddy fediment brought down by rivers, after fudden rains, or with the calcareous earth diffolved in many fprings. All thofe fprings, which pafs through marl, or chalk, or other limeftone, are replete with calcareous earth; which they hold in folution, as thofe about Derby and about Matlock, which earth they depofit on ftanding on the foil, or in flowly trickling over it. See Sect. X. 6. 2. And river water in rainy ſeaſons is loaded with diffuſed as well as with diſſolved materials from the neighbouring country.

Both theſe therefore are of great ſervice in flooding meadow-lands, and perhaps almoſt all other lands. But thoſe ſprings, which paſs only through ſiliceous ſandſtone, as thoſe at Lichfield in Staffordſhire, have no calcareous earth diſſolved in them, as I have found by experiment; and the water of moſt rivers, when they are not ſwelled by rain, are alſo too pure for this purpoſe; as they have depoſited already in their courſe the calcareous earth, which might abound in the ſprings, which feed them; as I have obſerved by experiments on the water of the Derwent at Derby, which though it runs for many miles about Matlock through a bed of limeſtone, yet when clear of mud from rains, it contains no calcareous earth, as it paſſes by Derby, though the ſprings in the vicinity are replete with it. Neither of theſe ſources of water can therefore do much ſervice for this ſecond deſign of depoſiting limeſtone, or mud.

The third advantage of flooding lands in this climate is for the purpoſe of defending them from the cold of the winter or vernal months. For this advantage the water from ſtrong ſprings, which are always at 48 degrees of Farenheit in this country, is preferable to river water, where it can be had in ſufficient quantity; ſince the water of rivers is of the ſame degree of cold as the atmoſphere, till the thermometer ſinks to 32. But both of them, when they form a ſheet of thin ice, as they cover a meadow, defend the roots of the graſs from ſeverer degrees of cold; which are thus preſerved, and thoſe of ſome graſſes are believed even to vegetate beneath the ice, as the rein-deer moſs in Siberia vegetates beneath the ſnow in a degree of heat about 40, which is the medium between that of the under ſurface of the thawing ſnow, which is 32; and that of the common heat of the interior parts of the earth, which is 48; and thus the rops of graſs in this cold climate may be wonderfully forwarded; ſo

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as almoſt to double the product of the year, if well managed and carefully attended to.

The method of forming the channels to convey the water conſiſts in carrying the firſt or principal aqueduct along the higheſt part of the meadow, and deriving others on the ſummits of the lands; if the meadow has formerly been ploughed into ridges and furrows, theſe again are to be divaricated ſo as to paſs into the furrows; all theſe branches of the ſtream are again to be collected from the furrows, and diſcharged at the loweſt part of the ſurface.

Something ſimilar to this muſt be managed on more level grounds, ſo as to conduct the water over the whole meadow, and alſo to carry it off, that it may not ſtagnate; but that a moving ſheet of water about an inch in depth may continually flow over the whole for the purpoſe of depoſiting the materials diſſolved or diffuſed in it. The conſtruction and width of theſe channels, with many uſeful obſervations, are ſhewn in a pamphlet of Mr. T. Wright, on "the Art of Floating Land in Glouceſterſhire." Scatcherd. London.

2. Mr. Wright in the treatiſe above mentioned adviſes, that the aftermath of graſs land ſhould be eaten off bare by the beginning of November, and that the channels for conducting the water to and from the meadows ſhould be then cleanſed and repaired; and that the water ſhould be ſuffered to flow over the meadow for three weeks; and that then the land ought to be expoſed to the air for a few days; ſince ſome of the graſſes, and thoſe of the moſt nutritive kinds, he believes will not much longer exiſt under water. By this early preparation, he adds, that advantage is taken of the autumnal floods, which bring along with them a greater quantity of putreſcent matter than thoſe of winter.

In the months of December and January Mr. Wright adds, that the chief care of the floater conſiſts in keeping the land ſheltered by the water from the ſeverity of froſty nights; but adviſes through the whole of theſe months every ten or fourteen days to expoſe the land

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to the air by laying it as dry as poffible for a few days; and always to difcontinue the flooding, when the land is covered with a fheet of ice.

In the month of February greater attention is required; if the water be fuffered to flow over the meadow for the fpace of many days without intermiffion, a white fcum is generated, and the grafs is much injured. And he juftly obferves that, if you now take off the water, and expofe the land in its wet ftate to a fevere frofty night, a great part of the grafs will be cut off.

Mr. Wright adds, that in Gloucefterfhire two methods of avoiding thefe injuries are practifed: one is to take off the water by day to prevent the production of the fcum, and to turn it over again at night to guard againft the froft. The other is to take off the water early in the morning; and, if the day be dry, to fuffer it to remain off a few days and nights; for if the land experiences only one drying day, the froft at night will do little injury. But the former of thefe practices, where it can be eafily done, he thinks preferable to the latter.

In the beginning of March the grafs on well-flooded meadows will generally be fo forward, as to afford abundant pafturage, and the water fhould be taken off for about a week, that the land may become dry and firm; and the cattle fhould for the firft week be allowed a little hay in the evening, if the weather be cold and rainy.

In the month of April the grafs may be eaten off quite fhort and clofe, but not later; fince if you trefpafs but one week in the month of May, the crop of hay, which is to fucceed, will be much impaired; and the grafs will become foft and woolly, and the hay have the appearance of lattermath hay, and be lefs valuable.

At the beginning of the month of May the water is again thrown over the meadows for a few days; which fimply by moiftening the land will in moft feafons, Mr. Wright obferves, enfure a crop of hay of one ton and a half on an acre in the courfe of fix or feven weeks.

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The water is fometimes again ufed, when the hay is carried off, but may render the lattermath, he thinks, unwholefome to fheep. But this is particularly ferviceable, when the water is rendered turbid by fuddens rains. Some have taken off two hay-crops in one year, but this Mr. Wright thinks is imprudent in this climate; which however I fuppofe might be accomplifhed, where the firft growth is not eaten in April, and where much turbid river water or calcareous fpring water can be ufed between them.

Mr. Wright further obferves, that the hay on thefe flooded meadows is little inferior to upland hay, if it be cut at its proper age; but that fome avaricious farmers have permitted it to remain uncut till it produces three tons on an acre, and that then it will become long and coarfe, and little better than ftraw. But that when it is cut in June, and has been flooded well with muddy water in the winter, that it becomes little inferior to the beft upland hay.

The hay, I fhould fuppofe, which is cut before the grafs is in full flower, while the faccharine juice ftill remains in part at the joints of the flower-ftems, muft contain the moft nutritious matter; which is afterwards abforbed as the flower expands, and as the feed ripens, and forms the meal or ftarch of the feed-lobe, and is fhed upon the ground, or confumed by birds, and the grafs-ftems and their leaves become fimply like the ftraw of ripened corn.

This will appear of more importance to any one, who attends to the difference of the pods or hufks of peas, or of kidney-beans, during the early ftate of the enclofed feeds, and again after the feeds become ripe. The pod or capfule is at firft fweet and mucilaginous, fo as to fupply an agreeable and nutritive food, the latter of which, and fometimes the former, are eaten at our tables; afterwards as the feeds, which are attached alternately to each fide of the capfule, drink up by their vegetable life after impregnation the faccharine and mucilaginous matters there purpofely depofited for them; the capfule itfelf becomes

becomes a mere fibrous membrane not better than the ftraw of ripe grains above mentioned.

It may be here repeated, that one great ufe in this country of flooding grafs-grounds in winter, and in early fpring, fo as to let a thin fheet of water perpetually flow flowly over them, is, that it will in frofty nights, when the cold is not much below the freezing point, produce a thin fheet of ice, and thus prevent the cold from affecting the roots of the grafs beneath it; which may thus be two or three weeks forwarder than on other lands; for ice is fo bad a conductor of heat, that water is not readily frozen beneath it; and efpecially if it ftands hollow, fo as to enclofe a ftratum of air between itfelf and the water beneath.

This feems to have been attended to by the philofophers in the French army, when they paffed over ice to fubdue Holland; fearing leaft the ice fhould be too weak for the paffage of their troops and artillery, they bored many holes through it every night; and then by preffure on its furface the water was made to rife through thefe holes, fo as to ftand an inch above the furface; which being thus expofed to the cold air of the night, became frozen before morning; and thus in a few nights thickened and ftrengthened the ice ten times more than would have been done naturally by the flower freezing beneath it.

3. To recapitulate the advantages of flooding, firft, not only the common meadow grounds are enriched, but moraffy ones are confolidated, by the mud brought over them from river water; or the calcareous fediment, and azotic or nitrogen air, from moft fpring waters, during thofe feafons when grafs does not naturally make much progrefs in its growth. 2. They are defended from froft by the flowing water, or by the ice, when it is frozen; and thus a much forwarder crop of grafs is produced, as may frequently be feen over pieces of ground naturally moift; which look green in the fpring,

fome

fome weeks before that on drier land in their vicinity. 3. The ground is rendered more eafily penetrable by the roots of grafs, both by its being kept fofter, and alfo from its being feldomer frozen below the furface in the vernal months. 4. This early crop may be eaten off by cattle or fheep, and a new flooding for a fhort time will forward the growth of it fo as to produce a good crop of hay. 5. After the hay is removed another flooding for a fhort time enfures a luxuriant growth of autumnal grafs, or aftermath.

The difficulty of getting moift lands free from rufhes is faid to be readily overcome by flooding them, and that efpecially after previoufly mowing them, as their fpongy pith will then abforb fo much water, as to caufe them to putrify by its ftagnation; or if this be done in autumn or fpring, and a froft fupervenes, the water in their pith by expanding, as it becomes ice, burfts and deftroys their organic ftructure.

The following conclufion is copied from Parkinfon's Experienced Farmer. "Upon the whole, artificial watering of meadows is a moft profitable improvement; it robs no dunghill, but raifes one for the benefit of other lands; for if a farmer can water ten acres of land, cut the grafs and ufe it either in ftall or fold-feeding, he might keep perhaps forty beafts; and by working the manure made by them into a compoft, and applying that compoft to other lands, he might either have a great deal more hay for the winter, or feed more cattle in the fummer." Vol. II. p. 68.

4. Two or three obfervations of importance fhould be here inferted. 1. That in flooding lands for a confiderable time, the water fhould only trickle over them from the canal, which leads it along the more elevated parts, and not ftand on it like a fifh-pond; as in the latter cafe the grafs roots will perifh in a few weeks in the early fpring, to the great injury of the farmer, an example of which on feveral acres I once witneffed.

As foon as any materials thus begin to putrefy beneath the water, a ſcum of white froth ariſes owing to the air ſet at liberty by putrefaction; which is ſuppoſed by ſome to injure the graſs, whereas it is a conſequence rather than a cauſe of injury, and ſhews, that the water has ſtagnated too long; and ſhould either be immediately drawn off, or ſupplied by a running ſtream; but the former ſhould probably be preferred: if the ſtems of graſs are ſo tall as to riſe above the running water, it is probable, that their death and putrefaction do not ſo ſoon occur.

Secondly. It is obſerved by gardeners, that in dry ſeaſons, if you begin to water any kinds of plants, you muſt continue to repeat it; otherwiſe that they are ſooner injured by dry weather, than thoſe which have not been watered. This fact alſo I think I have obſerved, and it may depend on the circumſtance of the roots of annual vegetables ſhooting themſelves lower down in dry ſeaſons in ſearch of moiſture; but if this be given them in the commencement of their growth, they then ſhoot their roots more horizontally, and are afterwards in conſequence ſooner deſtroyed by the ſubſequent dry weather.

Thirdly. Much cold water given ſuddenly to plants, which were nearly periſhing with heat and dryneſs, will I believe ſometimes injure or deſtroy them, as I ſaw occur this year, 1798, in June to ſome rows of garden beans; which after being flooded for one night withered, and in part died, on the following day, which was probably cauſed, not by the exceſs of water, as plants of this genus would ſeem to bear much moiſture from an experiment of Lord Kaimes, who ſays in the Gentleman Farmer, that he planted a pea on ſome cotton-wool ſpread on water in a phial, and that it ſprung up, and ſhot roots through the cotton-wool into the water, and produced large pods full of ripe ſeeds. The death of theſe beans was more probably occaſioned by the torpor of the ſyſtem induced by cold, as occurs to thoſe who have injudiciouſly drank much cold water, or plunged into a cold bath, when they have been previouſly much weakened by the

unneceſſary

unneceſſary activity of the ſyſtem occaſioned by continued heat, or great exerciſe. See Sect. XIV. 1. 1.

Nor is there reaſon to ſuppoſe that to whatever extent this mode of cultivation of graſs could be carried in this country, that any injurious effects in reſpect to the health of the inhabitants could be produced; as this mode of flooding is not by ſtagnant water, as in rice grounds; which D. A. J. Cavanilles, who has lately publiſhed a work on the cultivation of rice in the kingdom of Valencia, believes to be injurious to the health of the inhabitants. Magaz. Encyclop. T. 3.

In theſe cold climates the vicinity of running ſtreams may perhaps be rather ſalubrious than the contrary; as the air is cooled in hot weather, and warmed in cold weather, by its contact with their ever-changing ſurfaces, till they become frozen. I at this moment recollect many, who lived to an healthy old age in the valley of the Trent near the very edge of the water, whoſe names I could repeat. But ſtagnate waters, from which putrid exhalations ariſe, produce agues in cold countries, as in the fens of Lincolnſhire; and putrid fevers in hot ones; from which our armies ſuffered ſo much at St. Lucia both in the preſent and the laſt war.

5. This practice of flooding is capable of being extended to a wonderful degree in this country, not only by uſing the natural falls of brooks and ſprings, and by occaſionally damming them up to ſupply higher ſituations; and by effectually ſpreading the land-floods from accidental ſhowers over the inferior lands to a great extent. And laſtly, the water, which is now dammed up to ſupply the numerous mills, might be diffuſed in rills over a thouſand meadows, or part of it be raiſed by pumps to higher grounds; and thus fertilize and enrich the country; while the grinding of corn, ſpinning of cotton, rolling iron bars, and other mechanic purpoſes, might be effected by wind-mills, or ſteam-engines, in almoſt every part of the iſland.

For this purpoſe likewiſe the new method of raiſing water by the vis inertiæ or acquired momentum of moving ſtreams might be well applied, which was formerly ufed by Mr. Whitehurft of Derby on a fmall fcale at Oulton in Chefhire, as defcribed with a plate of the machine, to which an air-veffel is ingenioufly added, in the Philofophical Tranfactions for the year 1775, Vol. LXV. p. 277, and which is now adapted to variety of ingenious machinery by M. Boulton, Efq. of Soho near Birmingham; and is well explained with two prints in the Repertory of Arts and Manufactures, No. LI.

6. The following water machine, which is on the principle of Hiero's fountain, is defigned to raife part of the water of a fpring, or fmall brook, where fome feet of fall may be acquired, to a greater height for the purpofe of watering higher levels of ground; and the horizontal windmill with centrifugal pump is defigned for the fame purpofe, where no fall can be acquired. We fhall then perhaps have fatiated fome of our readers with this fubject of watering lands, and may conclude with the fhepherds in Virgil's Eclogue,

Claudite jam rivos, Pueri, fat prata biberunt.

SECT.

PLATE V.

PLATE V.

Repreſents the ſtrata of a hill. *a b* is the upper ſtratum, ſuppoſe of marle ; *c d* is the ſecond ſtratum, ſuppoſe of ſand ; *e f* repreſents the accumulated earth in the valley. It is deſigned to ſhew, that in boring holes through the upper ſtratum to find that beneath it, they ſhould be formed perpendicular to the ſide of the mountain, and not perpendicular to the horizon, as is the common practice, as by thoſe means the hole *y y* is much ſhorter than the hole *x x*. As explained in Sect. XI. 1. 5.

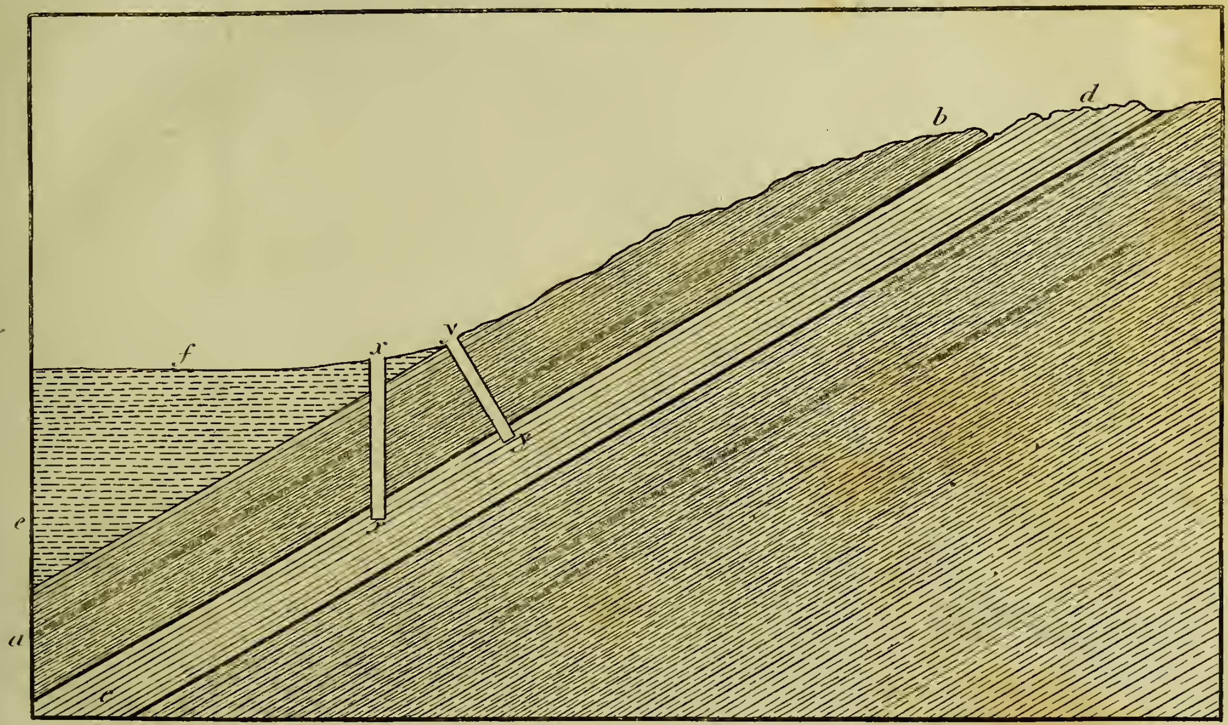

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PLATE VI.

PLATE VI.

Is a fection of a machine fimilar to Hiero's fountain, but defigned to raife water to a great perpendicular height, where there is the convenience of a fmall fall.

a b the ftream of water, *b c c* the height of the fall of it, fuppofe ten feet, *d e* two veffels of lead or iron containing, fuppofe, four gallons each, *f g h i k l* are veffels of lead containing, fuppofe, two quarts each, *o p* two cocks, each of which paffes through two pipes opening one and clofing the other, *q r* a water balance moving on its centre *s* and turning the two cocks *o* and *p*, alternately, *t u* and *w x* two air-pipes of lead one quarter or half an inch diameter within, *y z*, *y z*, *y z*, water-pipes one inch diameter.

The pipe *b c c* is always full from the ftream *a b*, the fmall cifterns *g i l*, and the large one *d*, are fuppofed to have been previoufly full of water, then admit water by turning the cock *o* through the pipe *c e* into the large ciftern *e*. This water will prefs the air, which was in this ciftern *e* up the air-pipe *w x*, and will force the water from the fmall cifterns *g i l* into the cifterns *h k* and great C. At the fame time by opening B, the water and condenfed air, which previoufly exifted in the large ciftern *d*, and the fmall ones *f h k*, is difcharged at B. After a time the water balance *q r s* clofes the cocks now open, and opens their antagonifts, and the cifterns *f h k* are emptied in their turn by the force of the condenfed air from the ciftern *d*, as the water enters into it from the pipe *b c*.

Plate VI.

Sect. XI. 3.6.

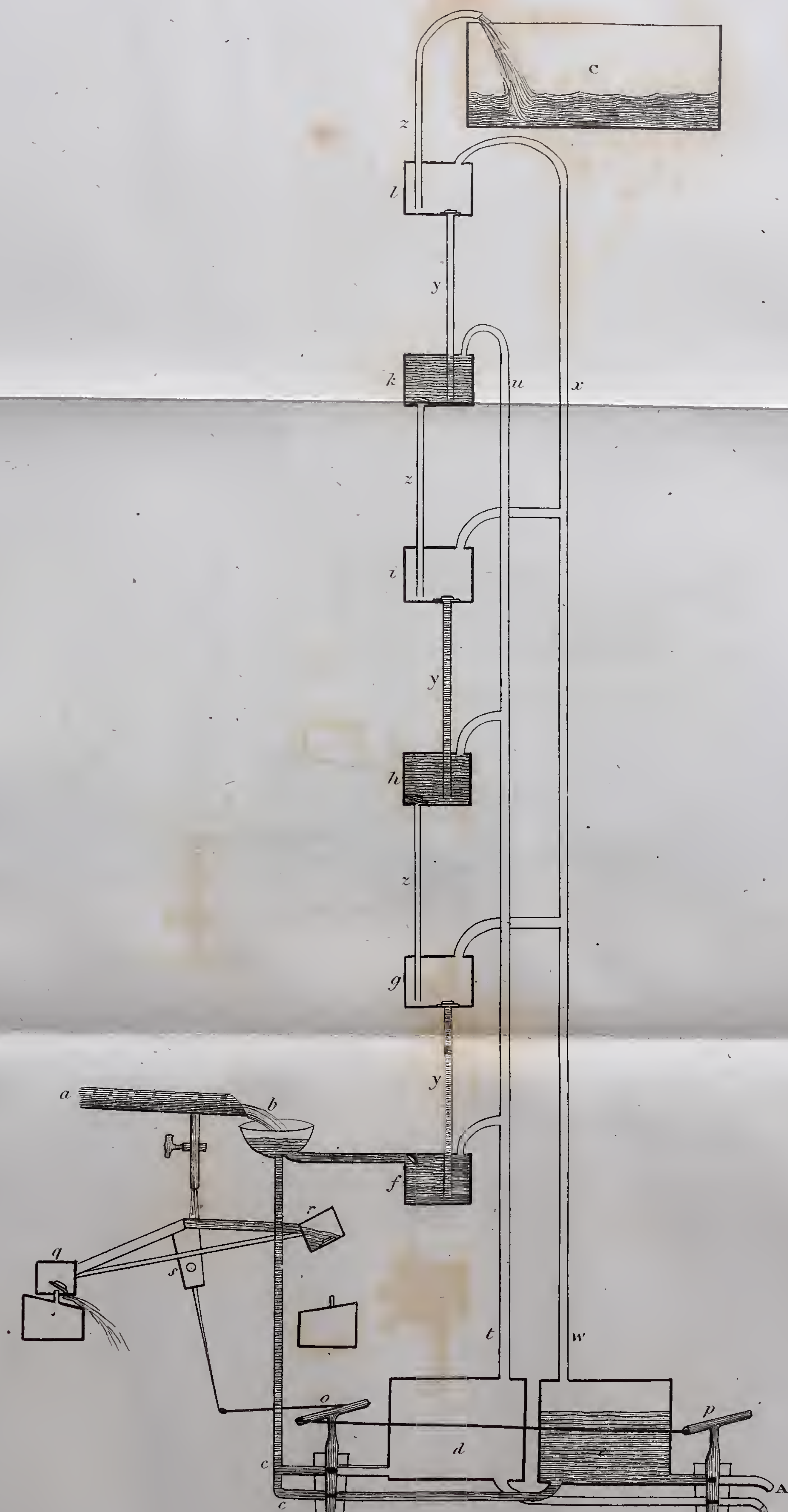

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PLATE VII.

PLATE VII.

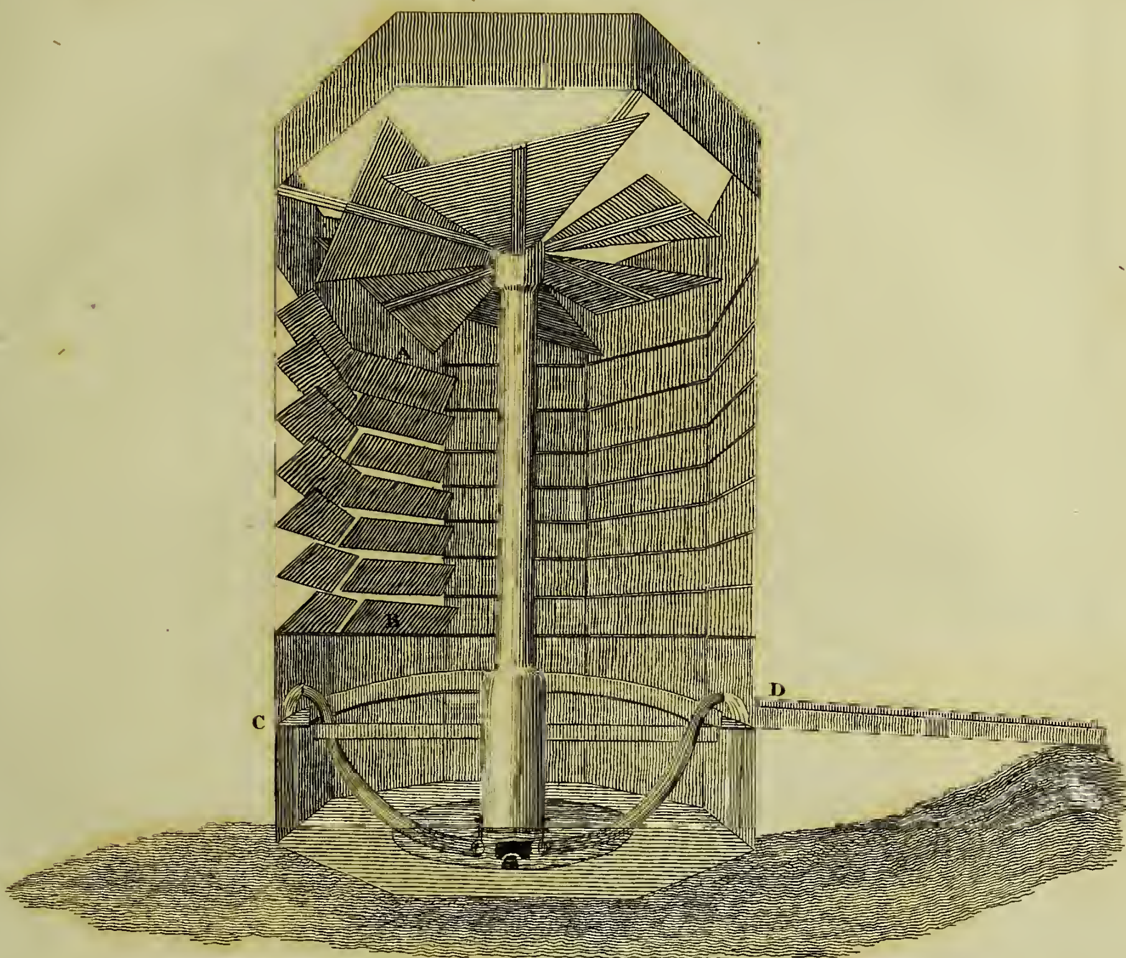
Is a fection of a machine for raifing water a few feet high by the power of the wind for the purpofe of draining moraffes, or of watering lands on a higher level.

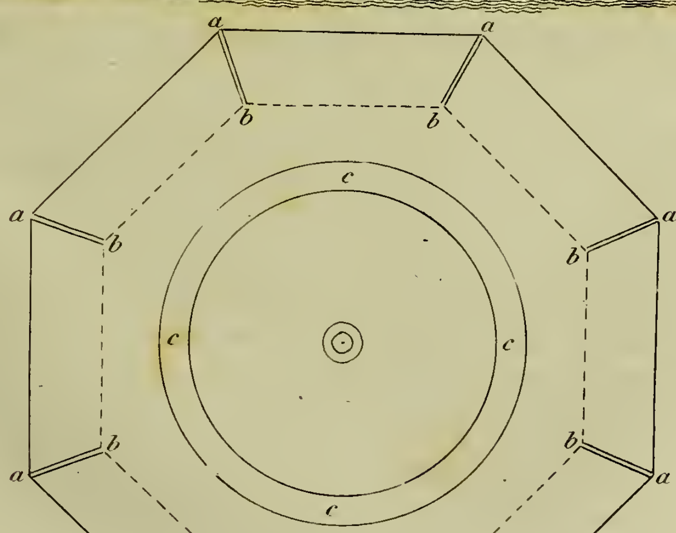
It confifts of a windmill fail placed horizontally like that of a fmoak-jack, furrounded by an octagon tower; the diverging rays of this tower, *a b*, *a b*, may confift of two-inch deals only, if on a fmall fcale, or of brick-work if on a larger one. Thefe upright pillars are connected together by oblique horizontal boards as fhewn at A B, by which boards placed horizontally from pillar to pillar, in refpect to their length, but at an angle of about 45 degrees in refpect to their breadth, fo as to form a complete octagon including the horizontal windmill fail near the top of it; the wind as it ftrikes againft any of them, from whatever quarter it comes, is bent upwards and then ftrikes againft the horizontal wind-fail. Thefe horizontal boards, which form the fides of the octagon, may either be fixed in their fituations, or be made to turn upon an axis a little below their centres of gravity, fo as to clofe themfelves on that fide of the octagon tower moft diftant from the wind.

It may be fuppofed that the wind thus reflected would lofe confiderably of its power before it ftrikes on the wind-fail, but on fixing a model of fuch a machine on the arm of a long whirling lever, with proper machinery to count the revolution of the wind fail, when thus included in a tower and moving horizontally; and then when moved vertically as it was whirled on the arm of the lever with the fame velocity, it was found on many trials by Mr. Edgeworth of Edgeworth Town in Ireland, and by myfelf, that the wind by being thus reverted upwards by a fixed planed board did not feem to lofe any of its power. And as the height of the tower may be made twice as great as the diameter of the fail, there is reafon to conclude that the power of this horizontal wind-fail may be confiderably greater, than if the fame fail was placed nearly vertically oppofed to the wind in the ufual manner.

At the bottom of the fhaft of the wind-fail is placed a centrifugal pump with two arms at C D, which has been defcribed in mechanical authors. It confifts fimply of an upright bored trunk, or cylinder of lead, with two oppofite arms with an adapted valve at the bottom to prevent the return of the water, and a valve at the extremity of each arm to prevent any ingrefs of air above the current of the water as it flows out.

c c c c is a circular trough to receive the ftreams of water from C and D, to convey them where required.





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SECT. XII.

AERATION AND PULVERIZATION OF THE SOIL.

I. *Soils contain inflammable matters and water. Air conſiſts of oxygen, nitrogen, and heat. Produces carbonic, nitrous, and phoſphoric acids, and volatile alkali with water when buried in the ſoil. Heat and light given out from the union of carbon and oxygen in a letter-wafer. Sow and ſet ſoon after the plough or ſpade.* 2. *Penetrability of the ſoil increaſed, and mixture of its ingredients. Retains the rains. Enlarges the ſurface.* 3. *Uſes of fallowing. Turnips ſaid not to impoveriſh the ſoil, why.* 4. *Fallowing injurious to rich lands, why.* 5. *The great advantages of Tull's drill huſbandry. Prefers horſe-hoeing to hand-hoeing. An improved drill machine.* 6. *Advantages of tranſplanting wheat.* 7. *Of harrowing wheat in ſpring.* 8. *Rolling wheat in ſpring.*

As almoſt all ſoils not only contain carbon, and other inflammable materials, which are capable of uniting with oxygen, and thus producing the carbonic and other acids; but alſo contain water, which by its decompoſition, when in contact with confined air, produces ammonia or volatile alkali by the union of its hydrogen with azote; and nitre by the union of its abundant oxygen with another part of the abundant azote or nitrogen of the atmoſpheric air; there is reaſon to conclude, that the great uſe of turning over the ſoil with the plough or ſpade depends principally in the production of theſe effects by the confinement of both the oxygen and the azote or nitrogen of the air in the interſtices of the ſoil; and on this account we have entitled this ſection the aeration of the ſoil rather than the oxygenation

 of

of it, as the latter belongs to the refpiration rather than to the nutrition of vegetables.

When atmofpheric air is imprifoned in the cavities of the foil by turning over its furface, which muft be in greater quantity, when the foil is reduced into the very fmall fragments, which has been called pulverization ; and when it is the leaft preffed down by animals trampling on it, it more readily unites, I believe, with the materials above mentioned than in its free ftate ; which is probably effected by double or triple chemical affinities.

For this atmofpheric air confifts of oxygen, azote, and the fluid matter of heat ; now if the heat, which occafions the oxygen and azote of the atmofphere to exift uncombined in the form of gaffes, be attracted from them by any other material, as they are confined in the cavities of the foil, they may by their nearer approach to each other combine into nitrous acid ; or the oxygen may in its fluid ftate, not in its aerial one, more readily unite with carbon ; and form a fluid, not an aerial, carbonic acid ; which we believe to be of fo much confequence in the growth of plants, as fhewn in Sect. X. 4.

Add to this, that if any putrefactive procefs be proceeding, where atmofpheric air is thus imprifoned in the cavities of the foil, and by the lofs of its heat is converted from a gas to a fluid ; that the azote may unite with the hydrogen of the decompofing water, or contribute to decompofe it ; and thus to form volatile alkali, which like the nitrous acid, may either during the procefs of its formation, or after it is formed, be of effectual fervice to vegetation, at the fame time the oxygen given out from the decompofing water may contribute like that of the atmofphere to produce carbonic, nitrous, or phofphoric acids ; and thus to render carbon, phofphorus, and the bafis of nitre, capable of being abforbed by vegetable lacteals.

Where atmofpheric air is confined along with water, I well remember from experiments I made long ago, by inverting a bottle filled with air in a jar of water, that the bulk of the air was in fome

days

days ſo much diminiſhed as to occupy only half the bottle, which probably occurs from the decompoſition of both the water and air; and the production of ammonia and nitrous acid, both which are believed to be ſo ſerviceable to vegetation, as mentioned in Sect. X. 2. 9.

That the heat of the atmoſpheric air is given out, when oxygen unites with carbon, is ſhewn by the heat of hot-beds; and of fermenting ſaccharine and mucilaginous fluids, as in the production of ardent ſpirit; and may be beautifully ſeen in the combination of oxygen with carbon in the burning of one of thoſe common letter-wafers, which conſiſt of the mucilage of flour, and red lead or minium; not one of thoſe, which are called Iriſh wafers, and which are coloured with vermilion. If one of theſe minium wafers be made to blaze in the flame of a candle, the oxygen contained in the minium unites with the carbon of the flour, and gives out a very luminous ſpark, and conſequent great heat, and at the ſame inſtant a ſmall globule of melted lead drops down, and may be agreeably ſeen, if received on a ſheet of white paper held under it. It is alſo probable, that heat is emitted during the production of nitrous and of phoſphoric acids.

From theſe obſervations it appears, that ſeeds ſhould be ſown, and roots planted, ſoon after the ſoil is turned over; while the production of the carbonic, nitrous, and phoſphoric acids, and of volatile alkali, and perhaps many other proceſſes, are proceeding, rather than after they are completed; and alſo while the fluid element of heat is paſſing from its combined ſtate, and permeating the ſoil, which in this cold climate in the vernal months muſt be highly conducive to vegetation.

2. By thus turning over the ſoil with the plough or ſpade the penetrability of it by the roots of plants is alſo much facilitated; and for this purpoſe, as well as for the admixture of atmoſpheric air, it can ſcarcely be reduced into too fine molecules, or a kind of wet powder;

der; for the moiſture of ſoil is as neceſſary for its being permeated by the young roots of plants, as its ſmall coheſion, as mentioned in Sect. X. 3. 6.

Secondly, a more intimate mixture of the various ingredients, which moſt ſoils poſſeſs, as carbon, calcareous, argillaceous, ſiliceous, and magneſian earths, with various metallic oxydes, as thoſe of iron, and ſometimes of mangaueſe, and calamy, all which by frequent turning over the ſoil with the plough or ſpade, become mixed ſo as to act on each other or on the roots of vegetables in every minute part of the ſoil.

And thirdly, the vernal rains are retained by their ſinking more readily into the pores and cells of land recently turned over, and which ſtill poſſeſſes an uneven ſurface. Beſides a greater ſurface of it being continually expoſed to the paſſing air, and to the heavier impurities, which it perpetually contains, as carbonic acid, ſoot, odours of many kinds.

3. A recapitulation of theſe circumſtances leads us to the knowledge of the uſe of fallowing lands, by repeatedly turning them over much carbonic acid is produced in its fluid ſtate; and perhaps ſome of the nitrous and phoſphoric acids; theſe may remain united with the vegetable recrements, or with volatile alkali, or with calcareous earth. 2. The parts of the ſoil may become better mixed together, and thus either chemically affect each other to their mutual melioration; or they may more uniformly ſupply nutriment to the roots, which penetrate it. 3. The ſoil may become broken into a moiſt powder, and may thus be more eaſily permeated, and ſupply a greater ſurface of its cavities for the vegetable abſorbents to apply themſelves to. 4. Unprofitable plants, or weeds, not being permitted to grow on it, or their being perpetually ploughed under the ſoil in their early growth, much vegetable nutriment will be reſerved by not being expended; or it will be increaſed by the ſaccharine and mucilaginous matter of the young plants, which are thus buried in it.

It

It ſhould be added, that ſome plants are ſaid not to impoveriſh the ground, on which they have grown during their herbaceous ſtate, before the ſeed-ſtems have ariſen; as turnips, when drawn up and carried away to feed cattle or ſheep on other grounds. This has been aſcribed by ſome authors to the ſoil having been ſhaded by their thick foliage, and thus not having ſuffered ſo much by evaporation. Some have aſcribed this ſuppoſed melioration of the ſoil to its having been ſcreened or overſhadowed by the thicker foliage of ſuch crops; and that as the putrefactive proceſs of vegetable recrements proceeds beſt in damp and confined air, as wood decays ſooneſt in cellars, they ſuppoſe the ſoil may thus become improved. But Mr. Tull ſeems either to doubt the fact, or to attribute it to the ground, where ſuch plants are cultivated, being uſually once or twice hoed; and thus in effect to have been followed by the repeated aeration and pulverization of the ſoil, and the deſtruction of innumerable weeds.

If neverthelefs the fact be true, not only all the circumſtances above mentioned may contribute to produce it, but alſo, as it appears by the experiments of Prieſtley and Ingenhouſe, that though the perſpirable matter of vegetable leaves gives out oxygen in the ſunſhine, yet that it gives out carbonic acid in the ſhade; which even in its aerial or gaſſeous form is much heavier than common air, and will therefore ſubſide on the earth in the ſhade of this perſpiring foliage, and contribute to enrich the ſoil by the hourly addition of carbon.

4. Neverthelefs where the ſoil is already replete with manures, and theſe proceſſes productive of carbonic, nitrous, and phoſphoric acids, and of volatile alkali, are going on in proper abundance; ſuch ſoils muſt be injured by being too frequently turned over in ſummer fallowing; and thus by expoſing too great a ſurface, and that too frequently, to the air, the ſunſhine, and the rain; by which much of the fluid carbonic acid will be converted into aerial carbonic acid, and eſcape, as well as the phoſphorus and the ingredients in their ſtate previous to the production of nitrous acid, and of the volatile alkali. On

this account in the manufacture of nitre in France, Spain, and Pruffia, it is directed to cover the compoft of foil and animal recrements with a fhed to prevent too great exhalation and ablution. Hence though a fummer fallow may be of advantage to a poor foil, which has nothing to lofe; it muft be difadvantageous to a rich one, which has nothing to gain.

Lord Dundonald in his work on the Connection of Agriculture and Chemiftry ingenioufly fuppofes, that foils become injured, when much expofed to the air by fallowing, from the carbon or other inflammable matters uniting with oxygen; and that then being again combined with other materials, they become infoluble, producing limeftone, calcareous nitre, and phofphat of lime. But there is another injury to foil by frequent fallowing, which I fufpect to be more extenfive, from the efcape of carbonic acid, or of nitrous acid, or of ammonia, into the atmofphere in the form of gas, as above mentioned; or their being wafhed away by rains.

5. Hence the great advantages of Mr. Tull's ingenious difcovery of the drill hufbandry are eafily underftood, 1. By fowing the wheat in rows, fcattered by a drill-plough at regular diftances, and buried at a regular depth, the grain is neither crowded, nor too thinly difperfed. 2. Nor are the roots buried either too deep in the foil, or too fhallow. 3. By turning the foil firft from the rows in the fpring for a week or two, and then turning it up againft the rows, the foil becomes newly aerated with all the good effects in confequence. 4. It becomes more penetrable by the fuperficial roots of the corn. 5. By raifing it to the fecond joint of the corn-ftems, four or fix new roots with new ftems will fhoot out, generated by the caudex of the fecond leaf of the corn-ftem; which is now within the foil, or in contact with it, as explained in Sect. IX. 3. 1. and 7. XVI. 2. 2.

Thus Mr. Tull's method of heaping foil againft wheat-plants up to the fecond joint anfwers in fome degree the fame purpofe, as tranfplanting the roots, and fetting them deeper in the foil with much

much lefs expence of labour. But for the more perfect pulverization of the foil, and the more complete aeration of it, he infifts much on the preference of horfe-hoeing to hand-hoeing; as the former paffes deeper into the foil, and thus expofes a greater quantity of it to the air; and efpecially of that part of it, which before lay too much beneath the furface to be previoufly much affected by the incumbent atmofphere. But the great objection to the ufe of the horfe-hoe is, that the alternate rows of corn muft be placed at too great a diftance, as will be again fpoken of in Sect. XVI. 2. 2.

To the many advantages of the drill hufbandry above recited Mr. Tull adds, that "where the fpring-turnips are ufed too late in the year, there is not time to bring the land into tilth for barley, and there is a lofs of the barley crop in confequence; which he fays is entirely remedied by the drilling method; for by that the land may be almoft as well tilled before the turnips are eaten or taken off, as it can afterwards." Hufbandry, Chap. VIII. p. 89.

So many great advantages feem to accrue from Mr. Tull's method of drill-fowing and horfe-hoeing, that a curious queftion offers itfelf, Why it has not been more generally adopted? Firft, I fuppofe, becaufe it is difficult to teach any thing new to adult ignorance, fo that the mafter muft for fome time attend the procefs with his own eye. Secondly, I believe the axle-tree of Mr. Tull's fowing machine did not accurately emit the proper quantity of feed from the hopper, and was liable to bruife and deftroy fome of it in its paffage. And thirdly, that the improved drill machine of Mr. Cook's patent is too expenfive for the purchafe of fmall farmers, who fear that it may not anfwer the expected advantages.

I have therefore given a print at the end of this work of a machine conftructed on a cheaper plan, which is fimply an improvement of that defcribed in Mr. Tull's book, by enlarging that part of the axle-tree which delivers the grain, into a cylinder of fome inches diameter with excavations in the rim; which rim riſes above the ſurface of the corn in the ſeed-box, and lets drop again into the ſeed-box, whatever grains fill the holes above the level of the rim, as that ſide of the cylinder aſcends. Whence the quantity delivered is uniform, and no grains are in the way to be bruiſed or injured, as explained at large along with the print; and the whole machine is ſimple, and of ſmall expence.

6. The moſt effectual method of obtaining the great combined advantages of aeration and pulverization of the ſoil is by tranſplanting the roots of wheat, and parting them, as already ſpoken of in Sect. IX. 3. 7. By taking up the roots and replanting them in ſoil lately turned over, and conſequently expoſed to the air, which is now confined in its interſtices, all the advantages already mentioned are effectually received, from the new made fluid, carbonic, nitrous, and phoſphoric acids, and from the ammonia, and other unnamed combinations. Secondly, all the advantages ariſing from the eaſy penetrability of the looſe ſoil by the root-fibres, which are believed by Mr. Tull to put out more radicles with abſorbent mouths at every part, where they are diſſevered, like a bruſh or pencil of hairs. Thirdly, by parting the root-ſcions from each other they acquire greater ſpace of air for their reſpiring leaves, and of ſoil for their abſorbent roots. Whereas when too many ſtems ariſe from one root, or many ſeeds are ſown near together, a tuſſock is produced in a conical form riſing higheſt in the center; which ſeems to be occaſioned by the conteſt of the ſtems for air and light; their roots alſo muſt deſcend lower in their conteſt for moiſture, and for other advantages of the ſoil; whence many of theſe crowded ſtems become barren, producing no ears, or ill-corned ones.

Another benefit from tranſplanting corn is owing to the quicker tendency to fructification, and conſequent ſooner ripening of the grain. Thus tranſplanted garden beans and tranſplanted brocoli flower ſooner, and I ſuppoſe produce leſs ſtems or ſtraw, as mentioned

tioned in Sect. XVI. 1. 2. I am alfo well informed by the Rev. Mr. Pole of Radborne, that the roots of thofe turnips, which were drawn out of the ground and tranfplanted, became confiderably larger than thofe, which were only hoed in the common manner; which I fuppofe to have been owing to many of the extremities of the roots having been torn off in drawing them out of the ground; and that thence the tendency to fhoot up the new central ftem is delayed, and the refervoir of nourifhment accumulated in the tuberous root is thus increafed in quantity, as feveral of thefe turnips weighed ten and eleven pounds; and hence probably the tranfplanting turnips by means of a cylindrical fpade defcribed in Vol. IV. of the Bath Society, which tears the roots lefs, might not have been fo advantageous. Something fimilar occurs in tranfplanting fruit-trees. See Sect. XV. 2. 4.

But the great advantage of tranfplanting wheat above the drill-hufbandry confifts in being able at the fame time to divide the root-fcions from each other; and thus not only to prevent their crowding each other, but alfo wonderfully to increafe the product from a fingle grain, with many other advantages mentioned by Mr. Bogle in the works of the Bath Society, Vol. III. p. 494.

Another great advantage of tranfplanting wheat confifts in this, that it may be fowed in a garden, one acre of which will produce fets for one hundred acres, if they be divided and planted at nine inches diftance from each other; and as they are not to be tranfplanted till the fpring, wheat may be thus cultivated in moifter fituations than would otherwife be friendly to its growth.

And that a clean crop may be certainly thus procured; becaufe if the land be ploughed immediately before the plants are fet out, the corn will fpring much quicker from the plants, than the weeds from their feeds; and the corn will thence bear down the growth of the weeds.

For many other particulars the reader is referred to the ingenious paper of Mr. Bogle above mentioned, who thinks the tranfplanting might be done by boys and girls at a fmall expence; I fhall only add, that rape-feed, which is generally fown in Auguft, and not reaped till the Auguft following, might be profitably tranfplanted, as well as peas and beans. And laftly, that it is probable, that fome means of making the holes to receive the plants might be much expedited by a broad wheel to be drawn by a man or horfe with prominent pegs on its periphery two inches tall, and nine inches afunder.

7. Another means of aeration and of pulverization has been ufed in refpect to wheat crops by many with advantage, and that is by drawing a lightifh harrow over a wheat-crop in the fpring, which, where a crop is thin, is particularly recommended; and may alfo be of fervice where it is too thick.

The harrow by breaking the clods, and by turning up the foil againft the ftems of many plants, earths them deeper as in hoeing; and thus by burying the fecond joint occafions it to tiller, or fhoot out new root-fcions; at the fame time the earth is expofed to the air, and many weeds are rooted up and covered, and fome roots of the corn.

The drawing a fharp harrow over a field of wheat in the fpring muft cut or tear many of the roots of thofe ftems, which it comes near, which according to Mr. Tull's theory would fhoot out many new radicles, or pencils of fine roots, and thus acquire more nourifhment. But I fufpect that tearing of many of the root-fibres prevents the too luxuriant growth of the ftem and leaves, and thence fooner produces the fructification, as in tranfplanting. At the fame time the earth being loofened becomes more penetrable to the remaining roots, as well as more nutritive from its aeration.

Others have even ploughed a field at this feafon with good effect, as Mr. Bogle afferts; but both of them appear to be only inferior kinds of drill hufbandry; and the former may fo far be of confiderable utility.

8. Another method of aerating and pulverizing the foil of a wheat field in fpring is by rolling it, which may be done before or after the

4 ufe

uſe of the harrow, or without it. As the ſurface of a wheat field is generally left rough with clods or eminences, the preſſure of a heavyiſh roller will not only pulverize theſe, and thus expoſe their interior ſurface to the air, and raiſe the ſoil round the wheat-ſtems above the ſecond joint, and thus induce them to ſhoot out new root-ſcions, or tiller ; but will alſo preſs down the wheat roots into the ſoil, and thus alſo promote the growth of new ſtems, as mentioned in Sect. XVI. 2. 5. if it be performed, when the ground is neither too wet nor too dry for ſuch an operation.

SECT XIII.

OF LIGHT, HEAT, ELECTRICITY.

I. 1. Light *and heat are different fluids. Light does not heat tranſparent bodies. A glaſs fire-ſcreen, combines with opake bodies, and heat is detruded.* 2. *Light combines with ſolid oxygen, and with heat converts it into gas. Perſpiration of plants is decompoſed by light. The hydrogen retained gives the green colour. Water hyper-oxygenated. Oxygenated marine acid. Colourleſs nitrous acid. A branch immerſed in carbonic acid and water.* 3. *Etiolation of vegetables. Bleaching owing to oxygen. Colour of plants to hydrogen, and the yellow tan of the ſkin. Pure air from dew. Perſpiration of plants oxygenated. Light tans living bodies, and bleaches dead ones, both vegetable and animal.* 4. *Uſe of light in vegetable reſpiration. Plants do not reſpire in the night. Truffles and fungi live without light.* 5. *Spring water frequently oxygenated. Air liberated by points.* 6. *Plants require oxygen. Fallacy of contrary experiments.* II. 1. Heat *univerſal. Counteracts gravitation. Is the cauſe of fluidity, and of aeriform ſtate. Particles of matter do not touch. Heat becomes combined. Is ſet at liberty in production of acids. In freezing water.* 2. *Froſt deſtroys fluidity. Ice expands. Separates compound fluids from each other, and burſts the veſſels of plants. Not of evergreens. Rime froſts and black froſts. Low ſituations not proper for gardens. Uſe of coping ſtones on fruit-walls. Rows of young peas from S. E. to S. W. Bend fig-trees on the ground. Froſt erroneouſly believed to meliorate the ſoil, and to be wholeſome. Clay rendered denſer by froſt. Snow protects plants. Animals covered with ſnow are not wet or ſtarved. Lichen rangiferinus* 3. *Cold deſtroys vegetable irritability. Heat is a ſtimulus. Acquired habits of plants.* 4. *Cold produced by evaporation. Plants not to be watered in the ſunſhine.* III. 1. Electricity *conſiſts of two fluids. Forwards the growth of plants whether poſitive or negative. Lightning deſtroys them.* 2. *It aſſiſts the decompoſition of water in vegetables.* 3. *Clouds* *are generally electrifed plus. Experiment on vapour. Rain from hydrogen and oxygen. Thunder fhowers.* 4. *Electric points to collect dew, and promote vegetation. Electric clock.*

I. 1. PHILOSOPHERS are not yet agreed, whether light and heat be the fame fluid under different modifications, or two different fluids, which exift frequently together. The latter opinion feems to be more probable from the circumftances related below, and alfo from the analogy of other aqueous, aerial, or ethereal fluids, which appear to confift of two other fluids combined or diffufed with each other. Thus water confifts of oxygen and hydrogen combined together. Atmofpheric air of oxygen and nitrogen diffufed together. Electricity probably confifts of two fluids, which may be termed vitreous and refinous electricity. Magnetifm alfo probably confifts of two fluids, which conftitute northern and fouthern polarity. The power of attraction feems to confift of gravitation and of chemical affinity. And laftly, the element of fire confifts I fuppofe of light and heat.

The diffimilarity of light and heat is evinced by this fimple circumftance; that as light gives no heat to tranfparent bodies, which the emanations from a fire do, there is reafon to believe them to be different fluids. Thus when fmoke is blown near the focus of a large burning glafs, it does not afcend; which fhews, that the air is not heated and rarified by it; though it would burn or vitrify in an inftant any opake body, which might be oppofed to it; but the emanations of heat from a fire foon rarify and warm the air in its vicinity, caufing it to afcend, as may be feen by a fpiral card-vann placed over a chimney-piece, and which is agreeably feen in the ufe of the new glafs fire-fcreens of Parifian invention, which placed before a parlour fire permit the rays of light to pafs, but intercept the emanations of fluid heat.

Whence it would feem, that light does not itfelf communicate heat to opake bodies, when it falls on them; but combines with them, and by that union heat is detruded or given out; which heat may produce inflammation of the material, if it be of an inflammable nature, by uniting it with the oxygen of the atmofphere; and thus producing an eduction of more heat from the oxygen, and greater inflammation of the burning body.

2. Another effential difference between light and heat confifts in the particular attraction of the former to oxygen; infomuch that by their union the combined or folid oxygen becomes changed into an aerial, or gaffeous ftate; as conftantly occurs, when the fun fhines on the hyper-oxygenated water, which is perfpired or exhaled from plants, as mentioned in Botanic Garden, Vol. I. Cant. IV. l. 25. But as an addition of heat feems neceffary to the converfion of a folid or fluid body into an aerial or gaffeous one, I fuppofe the fun's light at the fame time by combining alfo with the water fets at liberty fome latent heat from it, which gives wings to the oxygen.

The water perfpired by plants, when expofed to the funfhine, is believed to be decompofed, as it efcapes from the fine extremities of the exhalent or perfpirative veffels of plants; and that the hydrogen is reabforbed by the mouths of thofe veffels, as explained in Botanic Garden, Vol. I. note 34. That this happens to a certain degree is evinced by etiolated or blanched vegetable leaves becoming green, when expofed to the funfhine in a few days; which is, I believe, produced by their retaining the hydrogen of the water they perfpire, as it is decompofed by the fun's light.

But it is alfo probable, that the perfpired fluid of plants is previoufly hyper-oxygenated in the vegetable circulation. Firft, becaufe there is never perceived any fmell of hydrogen to attend this procefs of liberating oxygen by the fun's light. And fecondly, becaufe the following productions of oxygen gas by the fun's light are fimilar phenomena; though I fuppofe the points or hairs on vegetable leaves may contribute to the efcape of the oxygen, as explained in Botanic Garden, Vol. I. note 10.

Sir

Sir Benj. Thompfon, now Count Rumford, in a paper publifhed in Philof. Tranfact. Vol. LXXVII. put thirty grains of raw filk previoufly wafhed into fome fpring water, and expofing it fome hours to the funfhine obtained from it very pure vital air, or oxygen gas. In that experiment the fpring water feems to have been in a ftate of hyper-oxygenation, and the points or fine edges of the raw filk to have affifted its liberation from the water in the funfhine, as explained in Botanic Garden, Vol. II. note on fucus. 2. The hyper-oxygenated marine acid is known very haftily to part with its fuperabundant oxygen in the funfhine. 3. Mr. Scheele inverted a glafs veffel filled with colourlefs nitrous acid into another glafs-veffel containing the fame acid; and on expofing them to the fun's light, the inverted glafs became partly filled with pure air, and the acid at the fame time became coloured. Crell's Annal. 1786.

As water contains 85 hundredth parts of oxygen to 15 of hydrogen, it may become much oxygenated occafionally by a fmall lofs of hydrogen in the vegetable fyftem; or by the carbonic acid being decompofed in plants by the fecretion of carbon, which conftitutes fo great a part of them; and that on both of thefe accounts they may yield oxygen gas, when expofed to the fun's light, as appears from the following experiment related from Von Uflar by G. Schmeiffer. Obfervat. on Plants. Creech, Edinburgh, p. 92.

If two branches of a plant are immerfed, one in common water, and the other in water impregnated with carbonic acid, we then find, that the branch immerfed in the latter yields a much greater quantity of oxygenous gas in the funfhine than the other. The difference in fome experiments has been found in the proportion of 264 to 1. But the proportions vary when different plants are fubjected to trial. Thus the carbonic acid, with which the water is impregnated, is decompofed by the branch, the carbon apparently enters into the conftitution of the plant, while the oxygen is fet at liberty, and efcapes in the form of gas in the funfhine; but not in the night, as then the carbon is perfpired along with it.

3. A third circumftance, in which the effects of light differ effentially from thofe of heat, appears in the blanching or etiolation of vegetables; under whatever temperature of heat a plant is kept, it becomes white, if the light be excluded from it, and is fo far difeafed, as mentioned in Sect. XIV. 2. 4. Whence all vegetables turn towards the window, if confined in a room, and in denfe woods grow taller, than in open grounds, for the purpofe of acquiring accefs to this neceffary fluid. On this fubject many experiments are related by M. Senebier on vegetables confined in a dark cavern.

From the experiment laft related of the nitrous acid becoming coloured, when the fuperabundant oxygen was volatilized by the fun's light, or attracted from it; and from the experiments of bleaching cotton by the hyper-oxygenated marine acid, where the union of oxygen with the colouring matter feems to deftroy the latter by forming a new acid, which is colourlefs, it appears, that the abfence of oxygen occafions the colour of vegetable bodies, probably by the accumulation of hydrogen; and that on this account, when they are fecluded from the light, they become white, or blanched, or etiolated, by their not being in a fituation to part with fo much oxygen, as when they are expofed to the light.

Hence plants growing in the fhade are white, and become green by being expofed to the fun's light; for their natural colour being blue, the addition of hydrogen adds yellow to this blue, and *tans* them green.

I fuppofe a fimilar circumftance takes place in animal bodies; their perfpirable matter is probably hyper-oxygenated; and, as it efcapes in the funfhine, lofes its fuperabundant oxygen; and by the hydrogen being retained the fkin becomes *tanned* yellow. Though this muft occur in lefs quantity in animals, as they perfpire fo much lefs

than

than vegetables ; and the greateſt part of their perſpired matter, which exhales from the lungs, is not expoſed to the ſun's light. In proof of this it muſt be obſerved, that both vegetable and animal ſubſtances become bleached white by the ſun-beams and water, when they are dead, as cabbage-ſtalks, bones, ivory, tallow, bees-wax, linen and cotton cloth ; and hence, I ſuppoſe, the copper coloured natives of ſunny countries might become etiolated, or blanched, by being kept from their infancy in the dark, or removed for a few generations to more northern climates.

It is probable, that on a ſunny morning much pure air becomes ſeparated from the dew by means of the points of vegetables, on which it adheres, and much inflammable air imbibed by the vegetable, or combined with it ; and, by the ſun's light thus decompoſing water, the effects of it in bleaching linen ſeem to depend ; the water is decompoſed by the light at the ends or points of the cotton or thread ; and the vital air unites with the phlogiſtic or colouring matters of the cloth ; and produces a new acid, which is either itſelf colourleſs, or waſhes out ; at the ſame time the hydrogen or inflammable part of the water eſcapes. Hence there ſeems a reaſon, why cotton bleaches ſo much ſooner than linen ; viz. becauſe its fibres are three or four times ſhorter, and therefore protrude ſo many more points ; which ſeem to facilitate the liberation of the vital air from the inflammable part of the water.

A ſun-flower three feet and a half high, according to the experiment of Dr. Hales, perſpired two pints in one day, (vegetable ſtatics) which is many times as much in proportion to its ſurface, as is perſpired from the ſurface and lungs of animal bodies ; it follows, that the vital air, liberated from the ſurface of plants by the ſunſhine, muſt much exceed the quantity of it abſorbed by their reſpiration ; and that hence they improve the air, in which they live, during the light part of the day ; and thus blanched vegetables will ſooner become *tanned* into green by the ſun's light, than etiolated animal bodies will become *tanned* yellow by the ſame means.

Laſtly. This retention of the hydrogen on the ſkins of vegetables and animals, when their perſpirable matter is decompoſed by the ſun's light, and by which the former becomes green, and the latter yellow, is evidently owing to the power of life; becauſe when either of them are dead, the action of the ſunſhine on the water ſprinkled on them again blanches them, or bleaches them white.

It is hence evident, that the curious diſcovery of Dr. Prieſtley, that his green vegetable matter, and other aquatic plants, gave out vital air, when the ſun ſhone upon them; and the leaves of other plants did the ſame when immerſed in water, as obſerved by Mr. Ingenhouz, refer to the perſpiration of vegetables, not to their reſpiration. Becauſe Dr. Prieſtley obſerved the pure air to come from both ſides of the leaves, and even from the ſtalks of a water-flag, whereas one ſide of the leaf only ſerves the office of lungs, and certainly not the ſtalks. Exper. on Air, Vol. III. And thus in reſpect to the circumſtance, in which plants and animals ſeemed the fartheſt removed from each other, I mean in their ſuppoſed mode of reſpiration, by which one was believed to purify the air, which the other had injured, they ſeem to differ only in degree; and the analogy between them remains unbroken.

4. The conteſt for light, as well as for air, which is ſo viſible in the growth of vegetables, as deſcribed in Botanic Garden, Vol. II. note on cuſcuta, ſhews the former to be of great conſequence to their exiſtence as well as the latter. Thus many flowers follow the ſun during the courſe of the day by the nutation of the ſtalks, not by the rotation of them, as obſerved in the ſun-flower by Dr. Hales; and the leaves of all plants endeavour to turn their upper ſurface to the light, which is their reſpiratory organ, or lungs, as ſhewn in Sect. IV.

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The great ufe of all plants turning their upper furfaces of their leaves to the light is thus intelligible; the water perfpired from thofe furfaces is hyper-oxygenated; and, as it efcapes from the fharp edges of the mouths of the perfpiring veffels, when acted upon by the fun's light, gives out oxygen; which oxygen, thus liberated from the perfpired water, and added to that of the common atmofphere, prefents to the refpiratory terminations of the pulmonary arteries on the upper furfaces of leaves an atmofphere more replete with vital air.

This neceffity of light to the refpiration of vegetables is fo great, that there is reafon to believe, that many plants do not refpire during the night, but exift in a torpid ftate like winter fleeping infects. Thus the mimofa, fenfible plant, and many others, clofe the upper furfaces of their oppofite leaves together during the night, and thus preclude them both from the air and light. And the internal furfaces of innumerable flowers, which are their refpiratory organs, are clofed during the night, and thus unexpofed both to light and air.

The fungi neverthelefs, which are termed vegetables, becaufe they are fixed to the earth, or to the ftones, or trees, or timber, where they are found, can exift without light or much air; as appears in the truffle, which never appears above ground; and by other fungi, which grow in dark cellars; and in efculent mufhrooms, which are cultivated beneath beds of ftraw. From this circumftance of their exifting without light, and from their fmell of volatile alkali, like burnt feathers, when they are burnt, and from their tafte when cooked and eaten, they feem to approximate to the animal kingdom.

5. Laftly. It may neverthelefs be fufpected, that in many of the experiments of Dr. Prieftley and Dr. Ingenhouz, the production of vital air might be fimply owing to the action of the fun's light on the water, in which the vegetables were immerfed, like that from the filk in the experiment of Count Rumford; and that the fine points, or fharp edges of thofe bodies, contributed only to facilitate the

the liberation of it, when expofed to the funfhine, which thus dif-oxygenate the water by their united effect.

This appears on immerfing a dry hairy leaf in water frefh from a pump, innumerable globules like quickfilver appear on almoft every point; for the extremities of thefe points attract the particles of water lefs forcibly, than thofe particles attract each other; hence the contained air, whofe elafticity was but juft balanced by the attractive power of the furrounding particles of water to each other, finds at the point of each fibre a place, where the refiftance to its expanfion is lefs; and in confequence it there expands, and becomes a bubble of air. It is eafy to forefee, that the rays of the funfhine, by being refracted and in part reflected by the two furfaces of thefe minute air-bubbles, muft impart to them much more heat than to the tranfparent water; and thus facilitate their afcent by further expanding them; and that the points of vegetables attract the particles of water lefs, than they attract each other, is feen by the fpherical form of dew-drops on the points of grafs.

6. It may be added in this place, that there may alfo be a fallacy in the fuppofed refults of thofe experiments, where plants have been confined in hydrogen or azote mixed with atmofpheric air; and have been believed to have vegetated more vigoroufly, and to have meliorated the air. In thefe experiments I fufpect, that the impure part of the air was attracted by the water, and taken up by the abforbents of the roots of the plants from the water, rather than by the abforbents of their leaves or ftems in the air; and that the melioration of the air was occafioned, as above defcribed, by the action of the light on the water perfpired from the furface of the plant, or liberated by its points from the water, with which part of it was covered. This is rendered more probable, becaufe plants and feeds in the experiments of others ceafed to vegetate in thofe gaffes, which were totally deprived of oxygen, as in M. Scheele's experiments on the growth of feeds.

II. 1. The

II. 1. The fluid matter of heat is one of the moſt extenſive elements in nature, perhaps next to that of gravitation; all other bodies are immerſed in it, and are preſerved in their preſent ſtate of ſolidity or fluidity by the different attraction of their particles to the matter of heat, which thus counteracts the powers of gravitation, and of chemical affinity, which would otherwiſe compreſs them into one ſolid chaotic maſs!

Since all known bodies are contractible into leſs ſpace by depriving them of ſome portion of their heat; and as there is no part of nature totally deprived of heat; there is reaſon to believe, that the particles of bodies do not touch, but are held towards each other by their ſelf-attraction, or recede from each other by their attraction to the maſs of heat, which ſurrounds them; and thus exiſt in an equilibrium between theſe two powers.

If more of the matter of heat be applied to them, they recede farther from each other, and become fluid; if ſtill more be applied, they take an aerial form, and are termed gaſſes; and it is probable, that the ethereal fluid of electricity may alſo be diffuſed with heat, as well as the ethereal fluid of light.

Thus when water is heated to a certain degree, it would inſtantly aſſume the form of ſteam, but for the preſſure of the atmoſphere; which prevents this change from taking place ſo eaſily; the ſame is true of quickſilver, diamonds, and of perhaps all other bodies in nature; they would firſt become fluid, and then aeriform, by appropriated degrees of heat. On the contrary, this elaſtic matter of heat, termed Calorique in the new nomenclature of the French academicians, is liable to become conſolidated itſelf in its combinations with ſome bodies, as certainly in nitre, and probably in combuſtible bodies, as ſulphur and charcoal.

This combined heat is univerſally ſet at liberty in the production of acids by the union of oxygen with all inflammable bodies, as ſhewn in Sect. XII. 1. It is alſo taken from ſome bodies by the vicinity of very cold ones, as water when frozen lofes fuddenly a part of its combined heat, at the moment it becomes ice.

2. It is evident, that without fluidity the blood or juices can not circulate in animal or in vegetable veffels; whence fo great a diminution of heat as to produce froft on this account would deftroy them if long continued; at the fame time too great a deduction of heat is known to deftroy the irritability of animal as well as of vegetable fibres, and muft on this account alfo prevent the circulation of their fluids, and occafion the mortification of parts of them, or the death of the whole. But when fluids are converted into ice, the bulk of them is enlarged to a confiderable degree, and that with fuch violence as to burft iron veffels, as bombs, which are filled with water. Whence in this manner alfo froft deftroys thofe parts of vegetables, which are moft fucculent; as the early fhoots of afh trees, and other young plants, are frequently deftroyed in the beginning of May by a frofty night.

The veffels of thefe fucculent parts of plants are diftended and burft by the expanfion of their frozen fluids; while the drier or more refinous vegetables, as pines, yews, laurels, and other evergreens, are lefs liable to injury from cold. The trees in valleys are on this account more liable to injury by the vernal frofts, than thofe on eminences; becaufe their early fucculent fhoots appear fooner in the year.

Another method, by which the act of freezing may deftroy vegetable life, may be by feparating fome part of their fluids from other parts of them. Thus when wine, or vinegar, or falt and water, or clay diffufed in water, and perhaps milk, are frozen; the watery part, as it congeals, protrudes from its forming cryftals the fpirit, the acid, the falt, the clay, and probably the opake particles of the milk; and by a fimilar procefs on vegetable and perhaps on animal fluids, when expofed to great cold, they may be rendered unfit for future circulation or life. See Sect. XV. 4. 1.

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The expanſion of ice nevertheleſs well accounts for the greater miſchief which is ſometimes done by vernal froſt, when preceded by much rain, or miſt, or dew, as by hoar-froſt, than by the dry froſts without rime, called black froſts; as the vegetable veſſels are then fuller of fluids. But when miſt or dew attends a froſty night, but has not preceded it, I ſuppoſe a hoar froſt may be leſs injurious than a black froſt; as the caſe of ice on the buds of trees, or on young graſs, being inſtantly produced, covers them with a bad conductor of heat, and prevents them from being expoſed to ſo great cold, as in the continuance of a black froſt without hoar or rime. See Sect. XV. 3. 5.

Mr. Laurence, in a letter to Mr. Bradley, complains, that the dale-miſt attended with a froſt on May-day had deſtroyed all his tender fruits; though there was a ſharper froſt the night before without a miſt, that did him no injury; and adds, that a garden not a ſtone's throw from his own on a higher ſituation, being above the dale-miſt, had received no damage. Bradley, V. II. p. 232. From this inſtructive fact it appears, that very low ſituations even in this cold climate are not proper for the purpoſes of a garden. And on the contrary, very high ſituations are equally improper on account of their greater cold, and the conſequent backwardneſs of their vegetable products. See Sect. XV. 3. 5.

Hence fruit trees againſt a wall, which are covered with coping ſtones projecting ſix inches over them, are leſs injured by the vernal froſts; becauſe their being thus ſheltered from the deſcending night-dews has prevented them from being moiſt at the time, they were frozen; which circumſtance has given riſe to a vulgar error amongſt gardeners, who ſuppoſe froſt to deſcend.

Hence as the freezing winds of this country are from the north-eaſt, a gardener ſhould extend his rows of young peas and beans from the ſouth-eaſt to the north-weſt, and raiſe a mound of earth behind them, and might ſhelter them occaſionally with ſtraw, placed on the ground behind the young plants, and ſupported a few inches over them in front by poles placed horizontally over the rows; remembering the old proverb,

The wind from north-eaſt
Deſtroys man and beaſt;
The wind from ſouth-weſt
Is always the beſt.

The immediate cauſe of the coldneſs of the N. E. winds is, that they conſiſt of regions of air brought from the north over evaporating ice, and gain an apparent eaſterly direction, becauſe they arrive at a part of the ſurface of the earth, which moves with greater velocity, than the ſurface of the part of the earth, they come from. So on the contrary the S.W. winds are warm, as they conſiſt of regions of air brought from the ſouth, and gain an apparent weſterly direction, becauſe they arrive at a part of the earth's ſurface, which moves ſlower than the ſurface nearer the equator, whence they came, and of which they had previouſly acquired the velocity.

As the common heat of the earth in this climate is 48 degrees, thoſe tender trees, which will bear bending down, are eaſily ſecured from the froſt by ſpreading them upon the ground, and covering them with ſtraw or fern. This particularly ſuits fig-trees, as they are very flexible, and as they are furniſhed with an acrid juice, which defends them from inſects; but I have nevertheleſs found them in this ſituation much eaten by mice.

It has been believed by many, that froſt meliorates the ground; but it is now well known, that ice contains no nitrous particles, as was formerly ſuppoſed; and that though froſt by enlarging the bulk of ſome moiſt ſoils may leave them more porous for a time after the thaw; yet as the water exhales, the ſoil becomes as hard as before, being preſſed together by the incumbent atmoſphere. And from an obſervation of Mr. Kirwan's, mentioned in Section XV. 4. 1. it appears,

pears, that moift clay becomes denfer or more folid by being frozen; and if this fhould not occur, yet it would quickly become as folid as before by the felf-attraction of its particles, called *fetting* by the potters; as well as by the preffure of the atmofphere; as its water exhales, and leaves vacuities between its particles. Add to this, that on the coafts of Africa, where froft is unknown, the fertility of the foil is much fuperior to our own.

In refpect to the commonly fuppofed falubrity of frofty feafons to mankind, and to other animals, the bills of mortality are an evidence in the negative in refpect to mankind, as in long frofts many weakly and old people perifh from debility, occafioned by the diminifhed heat not being fufficient to excite into action their veffels previoufly too inirritable; and many birds, and other wild animals, and tender vegetables, perifh benumbed by the degree and continuance of the cold.

It fhould however be obferved, as frofty air is alway dry, except when frozen mifts diffolve, as they adhere to the warmer fkins of animals, that it does not generally affect us with fo great a fenfation of cold, as when air near the freezing point is loaded with moifture; as the moifture of fuch air is perpetually evaporating from our fkins, and produces on them a degree of cold greater than the fimple contact of dry air produces, when it is but a little beneath the freezing point. Hence frofty air is more agreeable to thofe young or ftrong people, who can keep themfelves warm by exercife; that is, who can generate heat by increafed fecretions. But fevere and continued frofts deftroy the old and infirm, who cannot ufe much exertion; and the children of the poor, who want both food, fire, and clothing, in this harfh climate.

It may neverthelefs be true, that fnows of long duration in our winters may be lefs injurious to vegetation than great rains and fhorter frofts. 1. Becaufe great rains carry down many thoufand pounds worth of the beft manure into the fea; whereas fnow diffolves gradually, the upper furface, as it thaws, fliding over the under part,

 which

which remains frozen, and thence carries away lefs from the land into the rivers; whence a fnow flood may be diftinguifhed from a rain flood by the tranfparency of the water.

Secondly. Snow protects vegetables from the feverity of the froft; fince it is generally in a ftate of thaw, where it is in contact with the earth; as the earth's heat is 48 degrees, and that of thawing fnow is 32°. The plants between them are generally kept in a degree of heat about 40, by which many of them are preferved. On this account fome plants from Siberia were faid to perifh by the frofts at Upfal; becaufe the fnows did not commence at the fame time as in the colder climate, from which they were brought.

Thus the lichen rangiferinus, coral-mofs, vegetates beneath the fnow in Siberia, where the degree of heat is always about 40; that is in the middle between the freezing point and the common heat of the earth. And as this vegetable is for many months of the winter the fole food of the rein-deer, who digs furrows in the fnow to find it; and as the milk and flefh of this animal is almoft the only fuftenance, which can be procured by the natives during the long winters of thofe higher latitudes, this mofs may be faid to fupport fome millions of mankind.

Snow protects vegetables, that are covered by it, from cold, both becaufe it is a bad conductor of heat itfelf, and contains much air in its pores. When living animals are buried in fnow, as fheep, or hares, the water, which their warmth produces, becomes abforbed into the furrounding fnow by capillary attraction, and the creatures are not moiftened by its dropping on them; but the cavity enlarges, as the fnow diffolves, affording them both a dry and a warm habitation. If this was generally known, many cold and weary travellers in fnowy nights might be faved by covering themfelves with fnow inftead of endeavouring to proceed.

It fhould be added that Haffenfratz has endeavoured to fhew by ingenious chemical experiments, that rain water and fnow contain both of them a redundancy of oxygen compared with river water, which they may have acquired in their defcent through the atmofphere; and that as oxygen is fhewn by the experiments of Ingenhouz and Senebier to promote the growth of feeds and of plants, he concludes, that rain water and fnow promote vegetation in a much greater degree than river water or ice, which feems to accord with the popular obfervations on this fubject.

3. Mr. John Hunter by applying thermometers to the internal parts of vegetables newly opened difcovered, that they poffeffed in frofty feafons a degree of heat above that of the atmofphere, though lefs than that of cold blooded animals. Whence another deleterious effect of cold on vegetable bodies muft be by deftroying their irritability, and by that means ftopping the abforption and circulation of their juices; in the fame manner as is feen in the pale benumbed fingers of fome people, when expofed to the cold; and which is the immediate caufe of death in thofe, who perifh in the fnow in winter, which occurs long before their fluids are frozen.

The neceffity of a certain degree of heat to produce or to preferve the activity of the abforbent veffels of vegetables is well evinced by the experiments of Hales and Duhamel on the rifing fap of vines in the vernal months. On a frofty day, when the fun fhone on one of thofe wounded trees, the fap flowed on the fouth fide of the tree, but not on the north fide. Phyfique des arbres, Vol. II. p. 258. M. Duhamel further obferves, that the maples in Canada, where the froft is long and fevere, begin to bleed, when wounded with the firft thaw, and ftop again, when it freezes; and that this in frofty days occurs only on the fouth fide of the tree.

This acquaints us, that one of the principal properties of heat in refpect to organic bodies, whether of vegetables or animals, confifts in its acting as a ftimulus; and that in a greater quantity than that, which the organized being has been accuftomed to, it acts as an excefs of ftimulus; and thus increafes the activity of the fyftem

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in refpect to the abforption of its food, circulation of its juices, and quantity of its fecretions, and confequently to its more rapid growth; but all increafe of ftimulus becomes injurious by its excefs, and is certainly followed by debility; as is feen in thofe of our own fpecies, who are habitually kept in too warm rooms, or are accuftomed to drink intoxicating liquors.

Hence a wife gardener muft regard the acquired habits of tender vegetables; the inhabitants of his green houfe, and thofe plants, which have been expofed to a greater heat for any length of time, fhould be gradually cooled, and watered with fubtepid water; fince expofing them to the cold of this climate is otherwife liable to deftroy their irritability and occafion their death.

4. The great cold produced by evaporation is now well underftood. In all chemical proceffes, where aerial or fluid bodies become confolidated, a part of the heat, which was before latent, becomes preffed out from the uniting particles; as in the inftant that water freezes, or that water unites with quick lime. On the reverfe, when folid bodies become fluid, or fluid ones become aerial, heat is abforbed by the folution; whence it may be faid in popular language, that all chemical combinations produce heat, and all chemical folutions produce cold. This fhould teach the careful gardener not to water tender vegetables in the heat of the funfhine, or in a warm dry wind; left the hafty evaporation fhould produce fo much cold as to deftroy them; and that more certainly from their having been previoufly too much ftimulated by heat, and in confequence their power of life, or irritability, having been already diminifhed; as further fpoken of in Sect. XIV. 2. 2.

III. 1. The mechanical theory of electricity invented by Dr. Franklin is believed by fome philofophers not fo well to explain the various phenomena of electricity, as may be accomplifhed by an hypothefis of the exiftence of two electric fluids diffufed together, and ftrongly attracting each other, one of them to be called vitreous, and the other refinous, electricity. The latter opinion I am inclined to efpoufe, but fhall not here enter into a detail of the theory; but fhall only obferve, that the experiments on vegetation have been principally made with the accumulation of the vitreous electricity only, and the confequent exclufion of the refinous; that is, with what is commonly termed pofitive electricity, and not with what is termed negative electricity. It is therefore to be wifhed, that fome future experiments may be made with the refinous or negative electricity in preference to the vitreous or pofitive electricity, or with both of them alter-ternately or comparatively.

The influence of pofitive or vitreous electricity in forwarding the germination of plants and their growth feems to be pretty well eftablifhed; though Mr. Ingenhouz did not fucceed in his experiments, and thence doubts the fuccefs of thofe of others; and though M. Rouland, from his new experiments believes, that neither pofitive nor negative electricity increafes vegetation; both which philofophers had previoufly been fupporters of the contrary doctrine; for many other naturalifts have fince repeated their experiments relative to this object, and their new refults have confirmed their former ones. Mr. D'Ormey and the two Roziers have found the fame fuccefs in numerous experiments, which they have made in the two laft years; and Mr. Carmoy has fhewn in a convincing manner, that electricity accelerates germination.

Mr. D'Ormey not only found various feeds to vegetate fooner, and to grow taller, which were put upon his infulated table, and fupplied with electricity; but alfo that filk-worms began to fpin much fooner, which were kept electrified, than thofe of the fame hatch, which were kept in the fame place and manner, except that they were not electrified. Thefe experiments of Mr. D'Ormoy are detailed at length in the Journal de Phyfique of Rozier, Tom. XXXV. p. 270.

Mr. Bartholon, who had before written a tract on this fubject, and propofed

propofed ingenious methods for applying electricity to agriculture and gardening, has alfo repeated a numerous fet of experiments; and fhews, that natural electricity as well as the artificial increafes the growth of plants, and the germination of feeds; and oppofes Mr. Ingenhouz by very numerous and conclufive facts. Ib. Tom. XXXV. p. 401.

My friend Mr. D. Bilfborrow in June 1797 fowed muftard-feed in four garden pots at Mr. Hartop's at Dalby Hall in Leicefterfhire. He fubjected one of thefe to pofitive or vitreous electricity, and another to negative or refinous electricity, and obferved that the feeds in the pot fubjected to the negative or refinous electricity germinated a day before the pot fubjected to pofitive or vitreous electricity, and both of them much before the two pots, which were not electrifed, but otherwife expofed to the fame circumftances.

Nor do the injuries occafionally received from lightning in its paffage through trees or corn fields from or to the earth or clouds, which are mentioned in Sect. XIV. 2. 3. in the leaft invalidate this opinion of its general utility as well as that of the fluid element of heat; for the excefs of the moft falutary ftimuli become deleterious both to vegetable and animal bodies.

2. Since by the late difcoveries in chemiftry there is reafon to believe, that water is decompofed in the veffels of vegetables; and that the hydrogene, or inflammable air, of which it in part confifts, contributes to the nourifhment of the plant, and to the production of its oils, refins, gums, fugar, &c. And laftly, as electricity has by late experiments been found to decompofe water into the two airs, termed oxygen and hydrogen, there is a powerful analogy to induce us to believe, that it accelerates or contributes to the growth of vegetation; and like heat may poffibly enter into combination with many bodies, or form the bafis of fome yet unanalyfed acid.

3. The folution of water in air or in calorique feems to acquire electric matter at the fame time, as appears from an experiment of Mr.

Mr. Bennet. He put ſome live coals into an inſulated funnel of metal, and throwing on them a little water, obſerved that the aſcending ſteam was electriſed plus; and the water, which deſcended through the funnel, was electriſed minus. Hence it appears, that though clouds by their change of form may ſometimes become electriſed minus, yet they have in general an accumulation of poſitive electricity. This accumulation of electric matter alſo evidently contributes to ſupport the atmoſpheric vapour, when it is condenſed into the form of clouds; becauſe it is ſeen to deſcend rapidly, after the flaſhes of lightning have diminiſhed its quantity.

According to the theory of Mr. Lavoiſier concerning the compoſition and decompoſition of water, there would ſeem another ſource of thunder-ſhowers; and that is, that the two gaſſes termed oxygen gas, or vital air, and hydrogen gas, or inflammable air, may exiſt in the ſummer atmoſphere in a ſtate of mixture, but not of combination; and that the electric ſpark, or flaſh of lightning, may combine them, and produce water inſtantaneouſly.

4. A profitable application of electricity by the gardener or agricultor to promote the growth of plants is not yet diſcovered; it is nevertheleſs probable, that in dry ſeaſons the erection of numerous metallic points on the ſurface of the ground, but a few feet high, might in the night time contribute to precipitate the dew by facilitating the paſſage of electricity from the air into the earth; and that an erection of ſuch points higher in the air by means of wires wrapped round tall rods, like angle rods, or elevated on buildings, might frequently precipitate ſhowers from the higher parts of the atmoſphere.

And laſtly, that ſuch points erected in gardens might promote a quicker vegetation of the plants in their vicinity by ſupplying them more abundantly with the electric ether; if the events of the experiments of the philoſophers above mentioned are to be depended upon, which may at leaſt be worth a further trial.

5. For the purpofe of keeping a few flower-pots perpetually fubject to more abundant electricity, Mr. Bennet of Wirkfworth in Derbyfhire affixed a fmall apparatus to the pendulum of a clock, as defcribed below with a plate; but has not yet fufficiently attended to it to determine its effect on vegetation.

SECT.

PLATE VIII.

PLATE VIII.

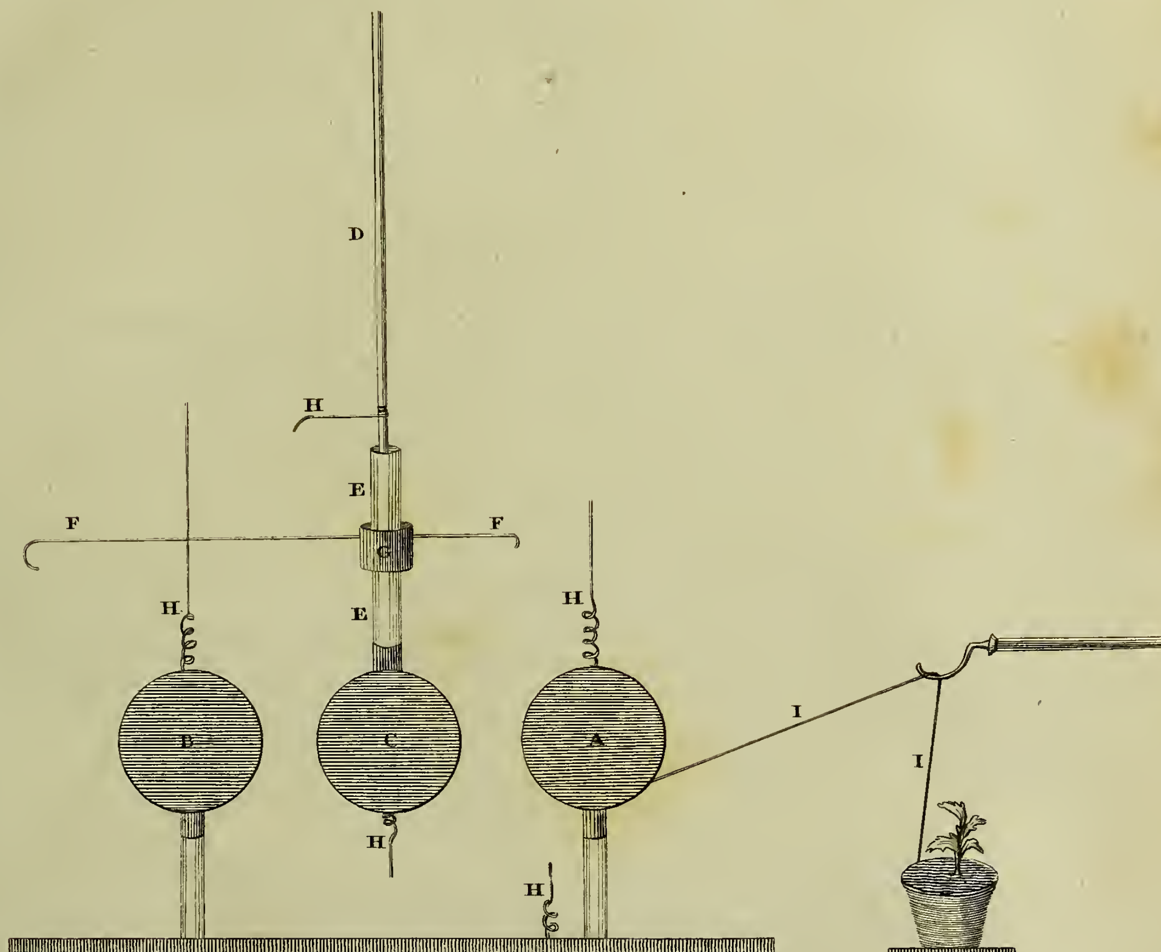
Shews the ftructure of Mr. Bennet's electric Doubler, applied to the pendulum of a clock for the purpofe of fubjecting a flower-pot to perpetual pofitive or negative electricity.

A the brafs plate, which is always infulated by its glafs pedeftal, on which the electricity is accumulated. B the brafs plate, which becomes electrified by the influence of the moving plate C, which is alfo infulated. D the pendulum wire. C is infulated by the glafs-tube E E. The wire F F is alfo infulated by the fame glafs, being faftened to the middle of it by a brafs focket at G. H H H H H are wires to connect the plates with each other, or with the earth. I I a ftring to be carried from the plate A over infulated hooks to any part of a room, or to an infulated flower-pot.

Now if A be pofitive, and C moves, till it be parallel to it, and the wires at the bottom touch each other, then C becomes negative, and moving till it be parallel to B, and its wire touched by the uppermoft H, then B becomes pofitive; and when C returns to A, the electricity of A and B becomes united by means of the infulated wire F F touching H H. The longer end of F is bent fo as not to touch the wire of B, till the end is brought to it. Thus the pofitive electricity of A is increafed.

The wires are curled into feveral rings to make them more elaftic, as otherwife they would foon be pufhed out of their places, and the proper contacts not occur. The plates A and B may be fixed on heavy pedeftals, that they may be moved upon a fhelf to a proper diftance from the plate, which hangs by the pendulum wire. The heavier the pendulum and the larger the plates, the more electricity may be accumulated. With my fmall apparatus fixed to a Dutch wooden clock fparks are fometimes produced between the plates, and fometimes the clock has been ftopped by their attraction to each other. Perhaps the plates fhould not be circular, but fomething like a lady's fan, when expanded, the bottom being a part of the curve defcribed by the moving pendulum, with the fides directed towards the point on which it moves.

This drawing and defcription of his Pendulum Doubler was fent me by Mr. Bennet of Wirkfworth, and is referred to at the end of Sect. XIII. of this work. If another infulated flower-pot was connected with the plate B inftead of the wire at the uppermoft H, perhaps it might be kept in a ftate of minus, or negative electricity, at the fame time that the other flower-pot was kept in a ftate of plus or pofitive electricity.



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SECT. XIV.

DISEASES OF PLANTS.

I. Difeafes from internal caufes. 1. *Difeafed irritability. Irritability derived from oxygen. Exhaufted by too great ftimulus. Shade apricot flowers from the fun. Much water after a hot day injurious. Irritability accumulated by lefs ftimulus. Experiment on euphorbia. Habits of plants brought from the fouth. Taken to America. In the bleeding feafon. Vines in hot-houfes. Habits of plants. Irritability greater after being expofed to much cold, lefs after much heat. Greateft in the morning. Hybernating animals. Variation of heat contributes to health.* 2. *Eryfiphe mildew. A feffile fungus. Give light and ventilation. Drain the land. Sow early. Rubigo, ruft. Probably another fungus. Uredo frumenti. Blight.* 4 *Clavus, ergot. On rye, which it renders unwholefome. Afcribed to infects by Duhamel.* 5. *Uftilago, fmut. Afcribed to infects by Linneus. Is probably owing to want of impregnation. How prevented.* 6. *Gangrena, canker. Affects apple-trees from old grafts. From wounds. Bind living bark on the wound. Or paint the alburnum.* 7. *Suffufio mellita, honey-dew. If occafioned by the aphis? Succeeded by a black powder.* 8. *Exfudatio miliaris, miliary fweat. On vines in hot-houfes from too great heat in confined air.* 9. *Fluxus umbilicalis, fap-flow. From wounds in fpring, and after midfummer. Bind on fponge. Strangulate with wire.* 10. *Secretio gummofa, gum fecretion. Bind on lead. Sponge, Indian rubber. Apply folution of green vitriol. Bind on a new bark.* II. Difeafes from external elements. 1. *Draught and moifture.* 2. *Heat and cold. Shelter early bloffoms from the funfhine.* 3. *Lightning. Injures trees and wheat fields. By deftroying their irritability, like the ftimulus of fome poifons. By burfting their veffels. How to prevent.* 4. *Light. Etiolation of fea-cale.* 5. *Of acid clay. Of fterile fand.* 6. *Noxious exhalations, from lead-works, and lime-kilns.* 7. *Poifons of arfenic, muriatic acid.* 8. *Condiments. Alcohol. Opium. Sea-falt. Its ufe and effect on vegetables. Ufe in the worm of fheep.* 9. *External injuries. Wound grape-*

grape-ſtalks. Caprification. Pluck pears to ripen them. III. Diſeaſes from inſects. 1. *From their neſts and young. On roſes, on quince-bloſſoms, on aconite.* 2. *Aphis on peach trees. Slugs prefer withered leaves. Cows eat withered thiſtles. The poiſon of yew leaves. Hiſtory of the aphis. Means of deſtroying them. Aphidivorous larva and fly.* 3. *Caterpillars on apple-trees and gooſe-berries. Burn the leaves. Put a fringe round gooſeberry-trees. Deſtroy white butterflies. Cabbage caterpillars deſtroyed by ichneumon fly.* 4. *Inſects in hot-houſes. Smoke of ſulphur injurious to trees.* 5. *Beetles beneath the ſoil. Snails. Slugs. Roll turnips before ſun-riſe. Slugs prevented by lime or ſalt. Caught by a board. Fly on turnips. Roll them. Steep turnip ſeeds in liquid manure as in China.* 6. *Beetles. Fern-chaffer. Deſtroys crops of wheat. Sow wheat ſhallow. Roll it, or ſtrew ſalt in fine powder. Thrips phyſaphus on wheat. Corn butterfly. May-chaffers on hedges. Locuſt. Encourage hedge-birds, larks, rooks, hedge-hogs. Some caterpillars wholeſome to eat, others poiſonous. All very hardy and difficult to deſtroy.* IV. Deſtruction by vermin. 1. *Mice. Tuſſocks of wheat from their granaries. Encourage the breed of owls.* 2. *Water-rats like beavers, how driven from a fiſh-pond. They eat vegetables. Are attracted by ſcents. How to poiſon them. How to entrap them.* 3. *Moles never drink. Sometimes ſwim. Work before ſun-riſe. How to deſtroy them by traps.*

THE diſeaſes of vegetables may be divided into thoſe, which appear to originate from internal cauſes, thoſe from the external elements, and thoſe from the nidifications or depredations of inſects; to which may be added the depredations of other animals. We ſhall begin with diſeaſed irritability.

DISEASES FROM INTERNAL CAUSES.

I. 1. It has already been ſhewn, that the buds of vegetables are individual beings, and conſtitute an inferior order of animals; and that they poſſeſs irritability, and ſenſibility, and voluntarity, and have aſſociations of motion; as explained in Zoonomia, Vol. I. Sect. XIII. But as the three latter kinds of excitability are poſſeſſed in a ſo much

leſs

lefs degree by vegetable buds, than by more perfect animals, we fhall only confider the difeafes of their irritability.

M. Girtannir endeavoured to fhew, that animal irritability originates from the oxygen, which conftitutes fomewhat lefs than a third of the atmofphere, which they breathe. And M. Van Uflar has applied the fame idea to vegetable life; and has endeavoured to fhew, that their irritability alfo originates from the oxygen, which they acquire either by the refpiration of their leaves, or by the abforption of their roots. And indeed, as refpiration is every minute neceffary to animal life, there is reafon to believe, that fomething immediately neceffary to the exiftence of life is acquired by the lungs of animals from the atmofphere rather than from the food, which they digeft; and that this, which is believed to be the oxygen only, is mixed with the blood, and feparated again from it by the brain, and fpinal marrow, after having undergone fome change in the circulation or fecretion of it.

In the fame manner it is not improbable, but that the fpirit of vegetation may have a fimilar origin, probably from the uncombined oxygen of the air, refpired by the upper furfaces of their leaves; and not from that, which is abforbed by their roots in a more combined ftate; and that this oxygen is again feparated from their juices by the fenforium, or brain, of each individual bud, after having undergone fome change in the circulation or fecretion of it. See Sect. IV. 1. 2.

The circumftances attending vegetable irritability are fimilar to thofe belonging to the irritability of animals upon a lefs extenfive fcale, as detailed in Zoonomia, Vol. I. Sect. XII.

When vegetable fibres have been long ftimulated more than natural or ufual by increafe of heat, the fpirit of vegetation becomes exhaufted; and in confequence a flighter degree of cold will deftroy them; becaufe their fibres after having been long excited by a greater ftimulus will ceafe to act on the application of one, which is much lefs; whence after hot days tender plants are more liable to be deftroyed by the coldnefs of the night. Whence in more northern climates the gardeners fhade their tender vegetables, as the flowers of apricots, in the fpring-frofts from the meridian fun, as well as from the coldnefs of the night; which is generally the greateft about an hour before funrife.

In the hot days of June 1798 I twice obferved feveral rows of garden beans become quite fickly, and many of them to die, from being flooded for an hour or two with water from a canal in the neighbourhood; which I afcribed more to the fudden application of too great cold, after being much enfeebled, or rendered inirritable, by the exceffive heat of the feafon, than to the too copious fupply of water to the dry ground; to which fhould be added, that fome plants are more liable to be thus injured than others; as the ftrawberries, young cabbage plants, and onions, which were in the fame fituation, received benefit and not deterioration by being thus occafionally watered in that dry feafon.

On the contrary, when plants have been long expofed to a lefs ftimulus of heat than natural or ufual, the fpirit of vegetation becomes accumulated; and if they are too fuddenly fubjected to much greater heat, their too great increafe of action induces inflammation, and confequent mortification, and death; as occurs to thofe people, who have had too much warmth applied to their frozen limbs. Experiments of this kind were inftituted by Van Uflar; he increafed the irritability of euphorbia peplus and efula by fecluding light and heat from them; and, when he expofed them to a meridian fun, they became gangrenous, and died in a fhort time.

This greater or lefs irritability of plants is to be afcribed to their previous habits in refpect to the ftimulus of greater or lefs heat. Thus the times of the appearance of vegetables in the fpring feem occafionally to be influenced by their previoufly acquired habits, as well as by their prefent fenfibility to heat. For the roots of potatoes, onions, will

will germinate with much lefs heat in the fpring than in the autumn; as is eafily obfervable, where thefe roots are ftored for ufe; and hence malt is beft made in the fpring, as the barley will then germinate with a lefs degree of heat.

The grains and roots brought from more fouthern latitudes germinate here fooner than thofe, which are brought from more northern ones, owing to their acquired habits. Fordyce on Agriculture. It was obferved by one of the fcholars of Linneus, that the apple trees fent from hence to New England bloffomed for a few years too early for that climate, and bore no fruit; but afterwards learnt to accommodate themfelves to their new fituation. (Kalm's Travels.) Vines in grape houfes, which have been expofed to the winter's cold, will become forwarder and more vigorous than thofe, which have been kept during the winter in the houfe. (Kennedy on Gardening.) This accounts for the very rapid vegetation in the northern latitudes after the folution of the fnows.

The increafe of the irritability of plants in refpect to heat, after having been previoufly expofed to cold, is farther illuftrated by an experiment of Dr. Walker's. He cut apertures into a birch-tree at different heights; and on the 26th of March fome of thefe apertures bled, or oozed with the fap-juice, when the thermometer was at 39; which fame apertures did not bleed on the 13th of March, when the thermometer was at 44. The reafon of this I apprehend was, becaufe on the night of the 25th of March the thermometer was as low as 34; whereas on the night of the 12th of March it was at 41; though the ingenious author afcribes it to another caufe. Tranfact. of the Royal Society of Edinburgh, V. I. p. 19.

There is an obfervation in Mr. Tull's work, which he ingenioufly afcribes to the acquired habits of plants. "By the extremely hard winter of the year 1708 or 1709, fome lucern in Languedoc was killed, along with all the olive trees and walnut trees by the feverity of the feafon; though I could not hear that one walnut tree was killed in England. Perhaps thofe in France having been accuftomed to much hotter fummers were unable to endure the rigour of the fame winter, that did not deftroy the fame plants in England." Horfe-hoeing Hufbandry, Ch. XIII. p. 201.

By adapted experiments Medicus is faid to have found, that the irritability of plants is greater in the morning, lefs in the middle of the day, and much lefs in the evening. And Von Uflar found, that their irritability in refpect to their contractions was increafed in cool and rainy weather. Obferv. on Plants by Schmeiffer. Edinb. So the parts of animals become more fenfible to heat after having been previoufly expofed to cold; as our hands glow on coming into the houfe after having for a while been immerfed in fnow; and many infects, and other animals, which hide themfelves in the earth, and fleep during the winter, were obferved by M. Spallanzani to difappear at a feafon, when the heat of the atmofphere was much higher than in the fpring, when they again made their appearance.

Hence it follows, that plants, which are kept in a warm room during winter, fhould occafionally be expofed to cooler air to increafe their irritability; as otherwife their growth in the fpring is obferved to be very tardy. Mankind for the fame reafon requires the perpetual variations of the heat of the atmofphere to preferve or reftore the irritability, and confequent activity, of the fyftem. Whence the health and energy of men are greater, and their lives longer, in this variable ifland, than in the tropical continents, which poffefs greater warmth, and lefs variation of weather.

2. Linneus in the Philofophia Botanica has given names to but four internal difeafes, eurifiphe, mildew; rubigo, ruft; clavus, ergot, or fpur; and uftilago, fmut; to which may be added many others as defcribed below.

Eryfiphe, a white mucor, or mould, or mildew, with feffile tawny heads, with which the leaves are fprinkled; this is frequent in humulus, hop; lamium, dead nettle; gallopfis, arch-angel; lithofpermum,

thofpermum, ftone-feed; and acer, maple. This mucor is a plant of the fungus kind, which will grow without light, or change of air, like other fungufes; and with its roots penetrates the veffels of the vegetables to which it adheres. But thefe veffels are probably previoufly injured by internal difeafe. The methods of preventing or deftroying it muft confift in thinning the plant, or removing thofe in its vicinity, fo as to admit more light, and greater ventilation, which may at the fame time eradicate the mildew, and reftore the internal vigour of the plant.

As the greater dampnefs of fome land fupplies one permanent caufe of mildew, as well as its being too much overfhadowed by thick foliage, the methods of prevention muft confift in properly draining the land, and ufing drier kinds of manure, as coal-afhes and bone-afhes, as well as by thinning the crops. And laftly, it is recommended to fow early in the feafon for the purpofe of procuring forward crops; as this difeafe is faid more to injure late crops owing to the greater dampnefs of the ground in autumn.

3. Rubigo, ruft, a ferruginous powder fprinkled under the leaves, frequent in alchemilla, lady's mantle, rubus faxatilis, effula degener; and particularly in fenecio or jacobæa; and efpecially in a burnt woody foil.

This is probably another fungus fimilar to the former, or to fome kinds of lichen, which grows beneath the leaves of vegetables previoufly difeafed, and may probably be prevented or deftroyed by expofing the plant to more light, and greater ventilation, as in the mucor above mentioned.

An account is given by Mr. Lambert in the Tranfactions of the Linnean Society, Vol. IV. of a difeafe which may probably be fomewhat fimilar to the rubigo, which he calls uredo frumenti, or blight of wheat, and defcribes it to be a fungus, which covers the ftems of wheat in wet feafons, when it is nearly ripe, fo as to give the field an appearance of being covered with foot. The ftem of the wheat is ſaid to appear to be ſplit, and the growth of the plant to be much injured. He deſcribes the fungus to be linear-oblong, tawny-black.

4. Clavus, ergot, or ſpur, occurs when ſeeds grow out into large horns, black without, as in ſecale, rye, and in carex. This diſeaſe frequently affects the rye in France, and ſometimes in England, in moiſt ſeaſons, and is called ergot, ſpur, or horn-ſeed; the grain becomes conſiderably elongated, and is either ſtraight or crooked, containing black meal along with the white; and is ſaid to appear to be pierced by inſects, which are ſuppoſed to cauſe the diſeaſe.

Mr. Duhamel aſcribes it to this cauſe, and compares it to galls on oak-leaves; but this has not yet been eſtabliſhed by ſufficient obſervations. By the uſe of this bad grain amongſt the poor, diſeaſes have been produced, attended with great debility, and mortification of the extremities, both in France and England. Dict. Raiſon. Art. Siegle. Philoſ. Tranſact. Vol. LV. 106.

5. Uſtilago, ſmut, when the fruit inſtead of ſeed produces a black meal, as in wheat, barley, oats, ſcorzonera, tragopogon. Much is ſaid on this diſeaſe in the Dict. Raiſon of Bomare. Art. Bled, who recommends ſteeping the grain, before it is ſown, in brine; which is generally directed to have ſo much ſalt added to the water, as may increaſe its ſpecific gravity, till an egg will ſwim in it; or ſecondly, to ſteep the ſeed-wheat in lime water; or thirdly, which he thinks moſt efficacious, in an alkaline ley made by adding pot-aſh to lime-water.

In the ſyſtema naturæ of Linneus under the article Vermes, Zoophyta, Chaos uſtilago, there is a quotation from Munchhauſen, that the uſtilago is a black powder, which is found in the deſtroyed grains of barley, wheat, and other graſſes; and in the florets of tragopogon ſcorzonera. And that this powder being macerated in warm water for ſome days paſſes into oblong animalcules, hyaline in reſpect to colour, and playing about like fiſh, as may be ſeen by a microſcope; and

and are again mentioned in Linneus's diſſertation on the inviſible world.

There is an ingenious paper in the publications of the Bath Society, in which the author obſerves, that the ſmut in wheat only happens, when wet weather occurs at the time of the flowering of the wheat; which may burſt the anthers, and waſh away the farina. He thinks that ſteeping the wheat in brine or lime water is an ancient error, and can be of no uſe but to ſeparate light wheat from that which is good. For he found ſmutty ears and good ones growing from the ſame root; and thence it could not depend on any contagious material, or inſects eggs, adhering to the ſeed; and in ſome even the ſame ear contained both ſound and ſmutty corns. And laſtly, that ſome of the corns had one end ſmutty, and the other ſound; and he concludes, that it muſt be owing to the want of impregnation from the defect of the farina fecundans; and that the putrefaction ſucceeded the death of the grain.

From the obſervations of Spallanzani on leguminous plants the probability of this opinion is much confirmed. He found that the ſeed was produced by the female organ of the plant, long before it was impregnated; which could not happen, till the flower was open, and the anther-duſt ripe. Whence it is eaſy to conceive, that for want of impregnation, or the vivifying principle, the wheat-corn muſt putrefy like the addle eggs of poultry, which are unimpregnated, and thence die, and in conſequence putrefy.

If this diſeaſe of ſmut ſhould become a ſerious evil, it might poſſibly be prevented by ſowing the grain in diſtant rows; and after ſome days ſowing other rows between them of the ſame, or of another kind of wheat; by which means, if wet weather ſhould deſtroy the anthers of one ſet of rows, the alternate ones might ſupply farina to their ſtigmas, if the weather became favourable. See Sect. XVI. 8. 2.

Wheat diſcoloured by ſmut may be waſhed, and readily dried on a malt kiln, and may be thus eafily made marketable and equally good; for the living grain will not abforb much water in a fhort time; or it may be mixed with clean fand, and after being well agitated the fand may be feparated by a riddle; and if neceffary the fame fand may be wafhed and dried for repeated ufe.

6. Befides the four internal difeafes above fpoken of, as mentioned by Linneus; and the uredo of Mr. Lambert, there are probably many others, which have not yet been fufficiently attended to, as the canker, gangrena; the honey-fweat, exfudatio mellita; the miliary fweat, exfudatio miliaris; the fap-flow, fluxus umbilicalis; and the gum fecretion, fecretio gummofa.

The canker, which may be termed gangrena vegetabilis, is a phagedenic ulcer of the bark; which is very deftructive to apple-trees, and pear-trees, as it fpreads round the trunk or branches, and deftroys them.

Mr. Knight has obferved this difeafe to be moft frequent and fatal to thofe trees, the fruit of which has been long in fafhion; as they have been perpetually propagated for a century or two by ingrafting; which he believes to be a continuation of the old tree, though nourifhed by a new ftock; and that the canker is thus a difeafe of old age, like the mortification of the limbs of elderly people, and arifes from the irritability of a part of the fyftem.

But it feems more probably to be an hereditary difeafe, as the buds of trees being a lateral progeny, and more exactly refembling their parents, muft be more liable to the difeafes gradually acquired or increafed by the influence of foil or climate; and have not the probability of improvement, which attends the progeny of fexual generation.

It is neverthelefs frequently produced on trees by external violence, as by a ftroke with a fpade by a carelefs labourer, who is digging near them; but this probably may more eafily affect the old grafts above mentioned. When a deftruction of the bark is thus produced by external

ternal violence, it may poſſibly be cured by the application of a piece of living bark from a leſs valuable tree, bound on as mentioned in the next article, and in Sect. XVII. 3. 10.

The edges of theſe gangrenous ulcers of the bark ſhould be nicely pared with a knife, ſo as to admit the air, and to prevent the depredations of inſects and the lodgment of moiſture, which might promote the putrefaction of the ſtagnant juices, and ſpread the gangrene; this ſhould be ſo managed as only to cut away the dead lips of the wound, but not ſo as in the leaſt to injure the living bark. Some thick white paint may then be ſmeared on the naked alburnum or ſap-wood on a dry day, which may prevent inſects from inſerting their eggs into it, and produce maggots, which erode and deſtroy the wood; and may alſo prevent the dews and rains from rotting it. The paint ſhould nevertheleſs be ſo ſpread, as not to touch the edges of the wound; as it might injure their growth by its poiſonous quality; a quarter of an ounce of ſublimate of mercury, hydrargyrus muriatus, rubbed with about a pound of white lead paint, might render it more noxious to inſects. See Sect. XVII. 3. 9. and 10.

7. The honey-dew, which may be called ſuffuſio mellita, conſiſts of a ſaccharine juice, which I have ſuppoſed to be exſuded from the tree by the retrograde motions of the cutaneous lymphatic veſſels, connected either with the common ſap-veſſels deſcribed in Sect. II. or with the umbilical veſſels deſcribed in Sect. III. 2. 8. inſtead of its being carried forwards to increaſe the growth of the preſent leaf-buds, or to lay up nutriment for the buds, which are in their embryon ſtate; and may thus be compared to the diabœtes mellitus, or to the ſweating ſickneſs of the laſt century.

The ſaccharine and nutritious quality of the honey-dew, ſimilar to that of the ſap-juice, which riſes in the vernal months from the birch and maple, is evident from its taſte; and from the number of bees and ants, which are ſaid to feed on it, when it appears on ſome trees;

trees; and which ſhews, that its exſudation muſt be conſiderably injurious to the tree, as before mentioned in Sect. VI. 6. 3.

In a paper written by the Abbé Boiſſier de Sauvages, he deſcribes two kinds of honey-dew; one of which he concludes to be an exſudation from the tree, and the other he aſſerts to be the excrement of one kind of aphis, which the animal projects to the diſtance of ſome inches from its body on the leaves and ground beneath it; and which he believes the animal acquires by piercing the ſap-veſſels of the leaf. This paper is detailed in Wildman's work on Bees, p. 46. The circumſtances are diſtinctly deſcribed, and by ſo great a philoſopher as Sauvages of Montpellier, that it is difficult to doubt the authenticity of the fact. But that a material ſo nutritive ſhould be produced as the excrement of an inſect is ſo totally contrary to the ſtrongeſt analogy, that it may neverthelefs be ſuſpected to be a morbid exſudation from the tree; though theſe inſects might occaſionally prey upon it, and void it almoſt unchanged at thoſe ſeaſons, becauſe the inſects continued ſome months after the honey-dew ceaſed, and before it commenced, as mentioned below; and the upper ſurfaces of the leaves became covered with a black powder, which had before been covered with the honey-dew. And laſtly, becauſe on other trees, as on the peach and nectarine, at other ſeaſons of the year, no honey-dew is perceived, though the aphis much abounds to the great injury of the trees.

Early this morning, June 18, 1798, I obſerved a remarkable honey-dew on an extenſive row of nut-trees, corylus avellana, which grow by the ſide of a pond of water; the ſun ſhone bright, and the upper ſurface of every leaf, which was illumined by the ſun, was covered with a viſcid juice, which taſted as ſweet as diluted honey. From many of theſe leaves large drops hung from the point, and during that day and the following one much of this honey dropped down ſo as to moiſten the gravel walk beneath the branches of every tree, and ſeemed more fluid as the ſunſhine became warmer; and the leaves,

leaves, which were concealed from the ſun, appeared to have leſs of the honey-dew, and ſome of them none of it.

How long this honey-dew had continued before I obſerved it, I cannot tell, but probably many days, as the weather was then, and had been uncommonly dry and warm, and ſhining; and after two or three days, when the weather changed, the morbid exſudation, if ſuch it was, or the excrementitious depoſition of this viſcid honey, became checked and gradually diſappeared.

Beneath every leaf of this extenſive hedge of filberts I diſcerned fifty or a hundred aphiſes of all ſizes, and many of them had wings; but I could not perceive, that any of them had been on the upper ſurfaces of the leaves, where the honey only exiſted; nor were any bees, or butterflies, or ants, about theſe leaves; on which they muſt have adhered, if they had ſettled; which poſſibly they were aware of, as a hive of bees was at no great diſtance.

M. Duhamel obſerved a ſimilar ſweet juice drop in ſuch quantity from willows by the ſide of a river in very hot and dry weather, that children were buſy in catching or gathering it, and that it taſted like manna, but was more agreeable. He alſo mentions its dropping from nut-trees. Phyſique des arbres, Vol. I. p. 150. M. Reneaume, in the Memoires of the Academ. des Sciences, obſerved a ſimilar exſudation from the maple, and ſycamore; and adds, 1. That it was unctuous and ſweet. 2. That it was in the greateſt quantity on the leaves expoſed to the ſun, which appeared wet on their upper ſurfaces; and that it was not ſeen before ſun-riſe. 3. That bees collected it as anxiouſly as common honey. 4. And that ſome leaves died, whoſe diſcharge was very great. 5. That it exiſted in a very dry and hot ſeaſon. But neither of theſe philoſophers ſpeak of its being attended by the aphis.

The aphis this year was uncommonly numerous, the leaves of the peach and nectarine trees were half of them deſtroyed by this pernicious inſect, and became bliſtered and curled I ſuppoſe by their punctures;

tures; which were made ſome weeks earlier in the year, and by an aphis without wings, and differing ſomewhat in their ſhape, but without any appearance of honey-dew on thoſe trees. But I could not diſcover any punctures or other diſeaſe of the leaves of theſe nut-trees, and therefore doubt whether theſe inſects, though ſo numerous on the under ſurface of every leaf, could be the cauſe of the morbid exſudation, if ſuch it was, on their upper ſurfaces; and the more as I could not diſtinguiſh, that they preyed upon the honey thus produced; and I afterwards obſerved that they continued in immenſe numbers under every leaf, when the weather became cooler, and moiſter, and the honey-dew ceaſed to be viſible. But after a few weeks I obſerved the upper ſurface of every leaf became covered with a black powder like ſoot; whether this was a new material, or remained after the exhalation of the honey-dew, I did not determine by experiment. But if both the honey-dew and this ſubſequent black powder on the upper ſurfaces of the leaves, were the excrement of the aphis on the under ſurfaces of the leaves over the former, or owing to an exſudation from the tree, muſt be determined by further obſervations.

But as a ſecond period of ſap-flow is believed to exiſt about midſummer, or a depoſition of vegetable nutriment for the new buds, as deſcribed in Sect. III. 2. 8. there is reaſon to ſuſpect, that the honey-dew is owing to the inverted action of the external lymphatics occaſioned by the debility induced by the continued heat, and perhaps to the moiſture of ſituation. Whence the nutritive fluid is thrown upon the external habit inſtead of being applied to nouriſh the new buds, or to be laid up as a reſervoir for their uſe. And that if it be voided by the aphis, it is owing to their puncturing the ſap-veſſels with the fine proboſcis, which they poſſeſs, at this ſeaſon only, or in a diſtempered ſtate of the tree, and drinking more of it than they are able to digeſt. For a further hiſtory of this inſect ſee No. 3. 2. of this Section.

8. Exfudatio miliaris, miliary fweat, appears to be produced by too great and continued heat, as it exifts on vines in hot-houfes, which are kept too warm, or too clofe in refpect to their ventilation.

This fecretion has not the fweet tafte like that of the honey-dew, but confifts of mucilage; which, as the watery part evaporates by heat, remains on the plant in very fmall round hard globules, like millet feeds, whence their name. I once witneffed a very fimilar appearance of minute hard round globules on the fkin in a miliary fever, which eafily were rubbed off with the finger; and were probably occafioned, as in this vegetable difeafe, by too great heat, and the exclufion of air, as defcribed in Zoonomia, Vol. II. Clafs 2. 1. 3. 12.

In the evaporation of perfpirable matter, which in its difeafed ftate may be more mucilaginous than natural, in confined bed-rooms or hot-houfes, I fuppofe, the aqueous part only is exhaled, and the mucilaginous part remains in the form of a globule; in the fame manner as ftalactites are formed on the roofs of caverns from a folution of calcareous earth in water, fimply by the evaporation of the water.

9. Fluxus umbilicalis, fap-flow, this occurs, when the alburnum or fap-wood of trees is wounded in the vernal months, as in birch and maple, defcribed in Sect. III. 2. 2. and confifts of a faccharine and mucilaginous fluid fimilar to the honey-dew, or fuffufio mellita; and is often very troublefome, when vines in hot-houfes are pruned too late in the feafon, as the whole branch is liable to bleed to death, owing thus to the lofs of the fap-juice, which ought to be employed in nourifhing the young buds, and expanding their leaves.

When fome perennial plants have rifen but a certain height from the ground, if their ftems are much wounded, or cut off, the roots are liable to bleed to death from this difcharge of the umbilical fluid, or fap-juice, which ought to have nourifhed and expanded the new buds and foliage; as may be feen in cutting down the heracleum fpondylium, cow parfnep, in April; and on this account it has been recommended to mow down thiftles, and other weeds, which are troublefome from their numerous increafe, early in the fpring; as many of them will then die, and the reft be much weakened by the fap-flow, which attends their wounds at that feafon.

In refpect to trees another period of fap-flow is faid to exift, when the new buds are forming after Midfummer, as fpoken of in Sect. III. 2. 8. Whence wounds at this feafon alfo muft be injurious; where this lofs of fap-juice occurs in hot-houfes various applications have been recommended by gardeners. I fufpect that a bit of fponge bound upon the end of the cut branch, or on the wound, by means of fome elaftic bandage, muft be the moft certain application; or a wire twifted round the end of the branch cut off, fo tightly as to ftrangulate the whole circulation of juices, and confequently deftroy the part above the ligature.

10. Secretio gummofa, gum fecretion, a morbid production of gum, which differs from the fap-juice above defcribed, as it contains no faccharine quality, though like the former it exfudes from the wounded alburnum of deciduous trees; whether the wound be originally caufed by internal difeafe, or by external violence, as mentioned in the gangrene of the bark above defcribed.

Where this happens to cherry-trees, prunus cerafus, a gum exfudes like gum arabic; which in dry weather hardens, as it adheres, and thus prevents the further difcharge of this nutritive material; otherwife the tree weeps away its life, perifhing from deficient nourifhment. In fimilar manner a refin is emitted from the injuries or wounds of pine-trees, and fome other evergreens, with great injury to the growth, or the deftruction of the tree.

This exfudation of the gum or refin of trees, as it happens chiefly in fummer, is probably a part of nutritious fluid defigned for the new buds, which in moft deciduous trees are formed about this time, and fhould be prevented from continuing to flow by binding on the part, previoufly made fmooth by a knife, a metallic plate, as of the lead

in

in which tea is wrapped, ſo as to prevent rain or dew drops from diſſolving the indurated gum. A bit of ſponge, or of ſoft leather, or of Indian rubber, caoutchouc, might be bound on under the lead, till the wound is healed. Might not a ſtrong ſolution of green vitriol in water, or ſome ink, if applied to the extremities of theſe bleeding veſſels, ſtimulate them into contraction, and prevent the further effuſion of gum?

Another method might be worth trial, which is mentioned in Sect. XVII. 3. 10. A piece of bark from a ſimilar tree of inferior value might be cut out, ſo as nicely to fit the wounded part, after its edges were nicely ſmoothed, and might be tied on by a proper bandage, as the liſting cut from the edges of cloth, or flannel, ſo that its elaſticity might ſecure a perpetual preſſure without injury.

II. DISEASES FROM EXTERNAL ELEMENTS.

1. In climates liable to inceſſant rains or perpetual drought for a length of time many diſeaſes of vegetables muſt originate from the exceſs of moiſture, or to the want of it; which are not very frequent in this country. In moiſt ſeaſons the leaf-buds of plants, as of graſs and corn, as well as of trees and perennial vegetables, grow too luxuriantly; and the flowers and conſequent fruits or ſeeds are later, and contain more aqueous, and leſs mucilaginous and ſaccharine matter.

On the contrary, in dry ſeaſons the leaf-buds are leſs vigorous, and therefore in leſs quantity, as the crops of hay, and the quantity of ſtraw; but the fruits and ſeeds ripen earlier, and are of more grateful flavour, and more nutritious.

2. The effect of heat on vegetation is ſpoken of in Sect. XIII. 2. 2. The exceſs of that element is ſeldom much injurious to the vegetation of this country, unleſs it may contribute to increaſe the dryneſs of the ſoil, when there is a ſcarcity of moiſture. But the de-

fect of the element of heat, or in common language excefs of cold, is frequently deftructive to the early fhoots of the afh, fraxinus, and to the early bloffoms of many fruit-trees, as apples, pears, apricots; as thefe are either more fucculent, or have lefs irritability, or more fenfibility; on both which accounts they are more liable to be difeafed by cold.

The blights occafioned by froft generally happen in the fpring, when cold nights fucceed to warm funny days, as the living power of the plant has then been previoufly exhaufted by the ftimulus of heat, and is therefore lefs capable of being excited into the actions, which are neceffary to vegetable life, by the greatly diminifhed ftimulus of a freezing atmofphere.

In fome northern climates, where the long funny days fucceed the diffolving of the fnows, as in Denmark and in Ruffia, the gardeners are faid to fhelter their wall-trees from the meridian fun in the vernal months; which preferves them from the cold of the fucceeding night; and by preventing them from flowering too early avoids the danger of the vernal frofts.

The deftruction of the more fucculent parts of vegetables, as their early fhoots, and that efpecially when expofed to frofty nights, was fpoken of in Sect. XIII. 2. 2. and can only be counteracted by covering them from the defcending dews or rime by the coping-ftones of a wall, or matts of ftraw.

3. The blafts occafioned by lightning are more frequent, I believe, than is ufually fuppofed; as I am informed by thofe, who purchafe extenfive woods, that very many trees on being fawed through are found cracked, and much injured by lightning. I had laft year a ftandard apple-tree, and a tall apricot-tree, in full leaf blafted at the fame time by lightning, as was believed. They both loft all their leaves; the apple-tree neverthelefs put out a new foliage, and recovered, and bore fruit this year; but the apricot, which was nailed to a high wall, never fhewed any returning life.

Mr.

Mr. Tull afcribes one injury to the health of wheat plants, and frequently their death, to lightning; the effects whereof, he fays, may be obferved by the blackifh parts or patches vifible in a field of wheat, efpecially in thofe years which have more thunder-ftorms than ufual, and adds that againft this there is no remedy.

The erection of frequent metallic points could alone fecure a garden or field from this misfortune; which probably occurs more frequently on damp fituations, than on dry ones; as mentioned in the account of Fairy Rings in Botanic Garden, Vol. I. note XIII.

The manner in which lightning deftroys the life of vegetables may be fimilar to that, in which it deftroys animal life; which is I fuppofe by its great ftimulus exhaufting the fenforial power in the violent action it occafions, and thus producing total inirritability to the common ftimuli, which ought to excite the vital actions of the fyftem; fimilar to which, though with lefs expedition, feems to be the effect of fome poifons on the animal fyftem, as the diftilled water of lauro-cerafus, a folution of arfenic, the contagious matter of fevers, and even a common emetic; all which by their ftrong ftimulus feem almoft inftantaneoufly to render the ftomach, and other parts of the fyftem, nearly or entirely inirritable, or difobedient to their natural ftimuli.

It may alfo affect vegetables in another way fimilar to that, which probably alfo happens, when their young fucculent fhoots are frozen; that is, by burfting their veffels, as it paffes through them, by its expanfive power; as happens to the large branches of fome trees, and to ftone-buildings, and other bad conductors of electricity, when they are ftruck with lightning.

The expanfive power of electricity is not only fhewn by trees and towers being rent by lightning, but by the found, which fucceeds the paffage of it through air; fince a vacuum, or nearly a vacuum, in refpect to air muft previoufly be made by the prefence of the electric fluid; and the fides of this vacuum rufhing together, when the

 ftream

ſtream has paſſed, occaſions the conſequent vibrations of the air, which conſtitute ſound, whether in the audible ſpark of electricity, or the tremendous craſh of thunder. See Sect. XIII. 3.

4. The element of light, as well as that of heat, is neceſſary to vegetation. In this climate they both ſeem in general to be injurious only by their defect, and ſeldom by their exceſs. But as light acts as a ſtimulus on the more irritative or ſenſitive parts of plants, which appears by the expanſion of many flowers, and of ſome leaves, when the ſun ſhines on them; and by the nutation of the whole flower, as of the ſun-flower, helianthus; and by the bending of the ſummits of all plants confined in houſes towards the light; there may be diſeaſes owing to the exceſs of this ſtimulus, which have not been attended to; to prevent which the flowers of tragapogon ſalſafi, and of other plants, cloſe about noon. Other unobſerved diſeaſes may be owing to a defect of the ſtimulus of light; as a mimoſa, ſenſitive plant, which I had confined in a dark room, did not open its foliage, though late in the day, till many minutes after it was expoſed to the light.

The exceſs of light has not been obſerved to be attended by vegetable diſeaſes in theſe more northern latitudes; but the diſeaſe produced by the deficiency of it, which is termed etiolation, or blanching, has been ſucceſsfully uſed to render ſome vegetable leaves and ſtalks eſculent by depriving them of much of their acrimony, and of their coheſion, as well as of their colour; as is ſeen in the blanching of celery, apium; endive, cichorium; cinara, cardoon; ſea-cale, crambe.

The following method of the growth and etiolation of ſea-cale is tranſcribed from the letter of a friend; to which ſhould be added, that the young heads of this vegetable without blanching are equal or ſuperior to moſt kinds of brocoli, braſſica. "Sea-cale ſeed ſhould be ſowed the latter end of March or beginning of April in drills, and then earthed up. In autumn it ſhould be tranſplanted into high beds, one row of roots in a bed, about a foot aſunder, and in the

winter

winter it ſhould be covered up. It muſt be kept dry, that is, the beds made in the drieſt ground; it is not fit to be eaten till the third year after it is ſowed. The year before it is eaten it muſt be covered up in the beginning of winter, firſt with ſtable dung, which may be kept from preſſing on it by a few ſticks placed like a cone over each root; then with long litter two or three feet high; the higher the better, becauſe the more it is forced, the earlier it is fit to be gathered, and the whiter it will be. It is to be gathered about the beginning of January, and ſo on till May, one bed being kept under another. It ſhould be boiled and ſent up on toaſt like aſparagus, and is an excellent vegetable, and at an early ſeaſon."

5. The earth, on which vegetables inſert their roots, ſometimes preſents noxious materials to their abſorbent ſyſtem, as the acidity of ſome clays; into which when the roots of ſome fruit trees penetrate, they are ſaid to loſe their health, as mentioned in Sect. II. 9. by the death or decay or their root-fibres.

Pure ſiliceous ſands alſo prevent vegetation from their containing no carbonaceous matter, and by their ſo readily permitting the dews and rains to exhale from them, eſpecially in hotter climates, where they conſtitute a moving ſurface unfriendly to all organized life.

6. There are alſo noxious exhalations diffuſed in the atmoſphere in the neighbourhood of ſome manufactories; which are ſaid to injure the growth or deſtroy the life of vegetables; as the ſmoke from the furnaces, in which lead is ſmelted from the ore, from potteries, and from lime-kilns; to which may be added the marine ſalt, or marine acid, which abounds in the too great vicinity of the ſea.

To theſe belong the experiments of Dr. Peſchier of Geneva, who immerſed ſeveral plants in vapours of nitrous acid, of volatile alkali, and of ether, to the great injury or death of the plants. Journal de Phyſique par Delametherie, T. ii. p. 345.

7. Unwholeſome or poiſonous materials may be applied to vegetables ſo as to diſeaſe or deſtroy them; as their abſorbent ſyſtems like

thoſe

thofe of animals are liable to imbibe many noxious materials, as mentioned in Sect. II. 8. A flight folution of arfenic, fprinkled on a peach-tree in the fpring, deftroyed the branches which received it. A folution of liver of fulphur was equally fatal to the branches of a nectarine-tree, and alfo oil of turpentine.

Mr. Von Uflar affirms, that watering plants with a due quantity of oxygenated muriatic acid will increafe their irritability; and if carried beyond a certain degree will injure or deftroy the vegetable by giving it too much oxygen; which is known in due quantity to be a falutary material, and the moft neceffary of all others to vegetable as well as to animal life.

8. There are materials called condiments, which are believed to poffefs ftimulus without nutriment in refpect to animal bodies, as fpice, falt, bitters, as the hop, and probably opium and vinous fpirit. Thefe when taken into the ftomach increafe its activity, and render the animal for a time fat, and even ftrong; but as all increafe of ftimulus, beyond what is natural, is followed by debility; after a time the animal becomes weak, and emaciated; and enervated in mind as well as body; as is uniformly feen in thofe who are addicted to the ufe of much beer and wine, or of opium; and in a lefs degree where fpice, or falt, or bitters, are taken in too large quantity.

What then fhall we fay to the ufe of common falt in agriculture? as it is a ftimulus, which poffeffes no nourifhment, but may incite the vegetable abforbent veffels into greater action; it may in a certain quantity increafe their growth by their taking up more nutriment in a given time, and performing their circulations and fecretions with greater energy. In a greater quantity its ftimulus may be fo great as to act as an immediate poifon on vegetables, and deftroy the motions of the veffels by exhaufting their irritability.

After a time I fufpect vegetables will always be liable to difeafe from this ftimulating innutritive material; and that though it may increafe the early growth of the plant, it will injure its flowering or feed-

feed-bearing; and that hence, if it be ufed at all, it fhould be a little before the time, that the plant would acquire that part of its growth, which is wanted. Thus if the herb or young ftem only be wanted, as in fpinage, mercury, afparagus, apply falt early; if the flower be wanted, as in brocoli and artichoke, or in tulip or hyacinth, moiften them with a flight folution of falt, when the flower-bud is formed. When the fruit or feed is wanted, as in melons or cucumbers, or peas and beans, apply the folution of falt ftill later, and at all times with rather a parfimonious hand. See Sect. X. 7. 4.

Similar to this, where animals difeafed with fuperabundancy of fat are required, it is cuftomary, I am told, to feed poultry for the London markets by mixing gin and even opium with their food, and to keep them in the dark; but they muft be killed as foon as their corpulency is formed, or they foon become weak, and emaciated like human drunkards. And in fome countries, as in Languedoc in France, the livers of geefe and ducks are required to be enlarged and difeafed; as they are reckoned a dainty by modern epicures, as well as by the ancient ones, who fpeak of the tumidum jecur anferis; and for this purpofe the animals are kept in the dark, and crammed with more than their natural quantity of nutriment; but are faid to become lean, and to die, if not killed as foon as this difeafe is produced.

It is neverthelefs to be obferved, that fea-falt as well as other ftimulating condiments may be advantageoufly ufed as medicines, though injurious as common food. Thus it is afferted by Baron Schulz in the communications to the board of Agriculture, Vol. I. Part III. and IV. p. 318, that it deftroys the fafciola hepatica, or flewk-worm in fheep. Some have recommended one ounce of falt to be given every day diffolved in water, but it is probable, it might be ufed with greater advantage, if hay was moiftened with the folution, which would thus at the fame time fupply them with better nourifhment than generally falls to the lot of thefe difeafed fheep, on fuppofition that they would eat it.

The rot of fheep, I fufpect, arifes from the inactivity of the abforbent veffels of the liver of that animal; whence the bile is too dilute, efpecially in moift feafons; whence the flewk-worm, as I have feen in the fhambles, inhabits the common bile-duct, and at length erodes the liver, caufing ulcers; which from the fympathy of the lungs with the liver occafions a cough, and a hectic fever from the abforption of the matter. Hence the falt by its additional ftimulus may render the bile lefs dilute by promoting a greater abforption of its aqueous parts, as well as a greater fecretion of it; which however I fufpect would be much more efficacious, if about fixty grains of iron-filings made into a ball with flour was given every morning for a week along with the falt, as further explained in Zoonomia, Part III. Art. 4. 2. 6. 4.

Since writing the above account of common falt as a condiment, and the probable confequences attending the ufe of it, I have met with fome experiments publifhed by Lord Kaimes in his Gentleman Farmer, which feem much to confirm the preceding account. He watered fome Jerufalem artichokes, helianthus tuberofus, which were planted in feparate pots, with a folution of fixed vegetable alkali, others with volatile alkali, others with weak lime water, others with ftrong lime water, others with putrid urine, and laftly others with water impregnated with putrid animal and vegetable fubftances, I fuppofe as they exift in a dunghill. All thefe faline folutions at firft encouraged the growth of the refpective plants, fo as much to furpafs thofe in the pot, which was moiftened only with common water, as a ftandard to compare the others to; but by additional quantities of the folutions, they all, except the laft, gradually loft their vigour, and perifhed in the end, as I fuppofe, by the excefs of ftimulus.

There

There is alfo an experiment in the works of Mr. Anderfon, which feems to fhew, that common falt poffeffes no nutritive quality adapted to vegetable growth; and that in fome foils, or to fome vegetables, it would feem not even to act as a ftimulus or condiment. He marked out a circle of fix feet diameter in the middle of a grafs field, which he diftinguifhed by driving a ftake in the centre; on this circle he ftrewed common falt, fo as to lie nearly an inch thick on the ground. The grafs fprung up in this circle in the fame manner as in the other parts of the ground, and the place could only be diftinguifhed by the ftake, though it was left there for fome years. Encycl. Britan. Art. Agriculture. See Sect. X. 7. 5. of this work. This experiment is worthy to be repeated, left there might have been fome miftake attending it; as fo many authors have given experiments with contrary refults; and as fome other neutral falts were fhewn to promote vegetation in the experiments of Dr. Home.

9. Some difeafes from external violence have been already mentioned in this Section, in which the injury is a remote rather than a proximate caufe of the difeafe, as in the canker fometimes, and the fap-flow, and gum-fecretion. But fome other difeafes from external violence have been purpofely produced, as well as that of etiolation, and turned to advantage; as the bunches of grapes, which have acquired their full fize, are faid to ripen fooner, if the ftalk of the bunch be cut half through. Tournefort fays, that the figs in Provence and about Paris ripen fooner, if the buds be wounded with a ftraw dipped in olive-oil. And laftly, the figs in the ifland of Malta are made to ripen fooner by caprification; as fpoken of in Botanic Garden, Vol. II. note on Caprificus. And it may daily be remarked, that thofe apples and plums ripen fooner, which have been wounded by infects; and that pears will ripen confiderably fooner, if they be immaturely plucked from the tree, which muft be efteemed injurious to the life of the pear; and as the converfion of auftere acid juices of fruit into fugar in the procefs of ripening may be in part che-

mical, it may proceed more haſtily, when the life of the fruit is impaired or deſtroyed; as ſeems to occur in the drying of germinated barley, and in baking pears, as well as in bruiſing apples for the purpoſe of making cyder; which laſt effect might probably be much improved by the addition of warmth.

III. DISEASES OCCASIONED BY INSECTS.

1. Among the diſeaſes of plants Linneus adds in his Philoſophia Botanica the neſts of thoſe inſects, which depoſit their eggs in plants; whence a variety of excreſcences. Theſe are, 1. The galls of oak, of ground-ivy, ciſtus, trembling poplar, willow, and hawk-weed. 2. Bedequar of roſes, or briar-balls. 3. Follicles of piſtachia, and black poplar. 4. Contortions of ceraſtium, chick-weed, veronica, ſpeedwell, and lotus. 5. Scales of firs, willows, and roſes.

He then adds, that the duplicature and prolification of flowers is often occaſioned by inſects, as common chamomile, matricaria, is thus made proliferus; and that carduus caule criſpo bears larger florets, with the piſtils growing into leaves, by the wounds of inſects.

It muſt be obſerved, that theſe excreſcences on the leaves of ſome plants, or mutation of their manner of growth, are not always the conſequence of a ſimple wound or puncture of the inſects, but of the depoſition of their eggs, or young offspring; which afterwards continue to ſtimulate the growing plant into unnatural motions, and conſequently into unnatural growth; like the inflammation and conſequent new granulations of fleſh in the wounds of animal bodies; which, if the ſkin is prevented from ſpreading over them, will riſe into large ſubſtances of fungous fleſh; or beneath the ſkin, where it is looſe, as in wens.

Many flowers are deſtroyed or rendered unprolific by the depredation of inſects, as roſe-buds by the cynips; and I remember obſerving one dry ſummer, that every bloſſom of a large quince tree

was

was pierced by a fly, and rendered unprolific before the bloſſoms had opened. I have alſo ſeen the hood of the aconite, ſo replete with an acrid juice, pierced by inſects to plunder it of its honey.

2. The curling of the leaves of nectarine, and peach, and cherry-trees, with the cells or bladders on their ſurfaces, are formed in conſequence of the wounds inflicted by the aphis; in the ſame manner as the galls and bedeguars on the oak and ſweet-briar by other inſects, but without their nidification or the depoſition of their eggs; though from the ſudden and general appearance of theſe injuries they have been aſcribed to blights from inclement weather.

Some obſervers have believed nevertheleſs, that theſe affected leaves were previouſly out of health; which occaſioned them to ſupply a proper ſituation for thoſe inſects, which moleſt them; as I have frequently obſerved, that ſnails or ſlugs eat thoſe leaves, which have been plucked from cucumber plants, and are beginning to wither; in preference to thoſe, which are growing in perfect health.

Mr. Lawrence relates, that in June the leaves of ſome of his wall-pear-trees were much injured by a hail-ſtorm, which leaves were afterwards blighted, and become full of tumours from inſects; and the pears, which were then as large as walnuts, all periſhed. On this Mr. Bradley remarks, that inſects generally lay their eggs on the dead or putrefying parts both of vegetable and animal bodies; and adds a conjecture, that the parent inſects may circulate in the juices of the plant, which however is not probable, as though microſcopic animals have been diſcovered in the ſtagnating juices of animal bodies, as in the puſtules of the itch, and in the fæces in the dyſentery, and even in the ſemen, which may have ſtagnated in the veſiculæ ſeminales; yet no ſuch animalculæ have, I believe, ever been detected in recent blood, or any recent ſecretions from it.

A predilection for ſome withered leaves appears alſo in larger animals as well as in inſects; cows will eat young thiſtles, a few hours after they are cut down, as their prickles become flaccid; and horſes

refuſe

refuſe the young ſhoots of yew-trees, as they grow; but will eat them when they are cut off, and begin to wither; and on that account loſe a part of their acrimony; though there is ſtill often ſufficient poiſon within them to deſtroy the animal. And it is even probable, that when the leaves of yew are withered to a greater degree, their poiſonous acrimony becomes ſo far deſtroyed, that they ceaſe to be deleterious to horſes; ſo that in Heſſe in Germany it is cuſtomary in the winter to crop the young ſhoots of yew-trees, and mixing them with other provender to give them as common food to horſes. See Anderſon on Agriculture, Vol. III. p. 590.

On this account if wall-trees are frequently watered by an engine, ſo as to moiſten their leaves or branches as well as the ground at their roots on the dry days in ſpring, by which they will be kept in vigorous growth, I was told, that they would totally or nearly eſcape the depredations of inſects; but I found by an experiment well conducted on three trees, that this management had no effect; and I alſo obſerved in the ſpring and ſummer of this year, 1798, which ſeems to have much favoured the production of the aphis, that they attacked the moſt healthy leaves of peach and nectarine trees, as well as the others; and that plums, cherries, black currants, and many other trees ſuffered by their depredations, though previouſly in perfect vigour. And laſtly, that on repeatedly having waſhed off many thouſands of aphiſes from peach and nectarine leaves by a ſtrong ſtream from a forcible water-engine, that they evidently crawled again up the ſtems of the trees, or on the wall to which they were nailed, as in another day the lowermoſt branches were thus more infeſted with them than the upper ones.

The hiſtory of the aphis, puceron, or vine-fretter, is ſo curious, the deſtruction it commits on the foliage of the peach and nectarine is in dry ſummers ſo irreſiſtible, and its exiſtence on other trees ſo extenſive, that it demands our particular attention. See No. 1. 7. of this Section. From the obſervations of Swammerden, Bonnet, Dr. Richardſon,

Richardſon, and of other philoſophers, this extraordinary inſect riſes in the ſpring from eggs, which are ſaid to be attached by the parent aphis to the twigs of trees in the autumn, and are believed to produce not a larva or caterpillar, but a progeny ſimilar to the parent; every one of which produces in about ten days not an egg, but another living progeny to the ninth generation, without being connected amatorially with each other. The ninth generation produces males and females, ſome of both kinds with wings, and others without them; and this tenth generation from thoſe, which were hatched from eggs, become amatorially connected, and produce eggs; which are laid on the new twigs of various trees for the next year's progeny to be hatched by the vernal ſun. Philoſ. Tranſact. Vol. LXI. p. 182.

In this uncommon circumſtance the eggs of the aphis reſemble the ſeeds of plants; which firſt produce ſome ſucceſſive generations of leaf-buds, which are a viviparous progeny, before they again produce ſeeds, which are their oviparous progeny, as mentioned in Sect. IX. 3. 1. of this work. Nor is this to be aſcribed to what has been termed equivocal generation, or to an impregnation of nine fetuſes encloſed within each other, as ſome have ſuppoſed. But this central production of the viviparous progeny of the aphis ſeems to reſemble the lateral production of a viviparous progeny from the polypus, which in time detach themſelves from their parents; like the buds of the polygonum viviparum, or the bulbs of the magical onion, allium magicum; which are produced from the flower-cup inſtead of ſeeds, and in time detach themſelves, and fall on the ground. So that theſe aphiſes are not, I ſuppoſe, to be eſteemed fecundated females, but proliferous males, as explained in Zoonomia, Vol. I. Sect. 39. on generation.

This double mode of reproduction, ſo exactly reſembling the buds and ſeeds of trees, accounts for the wonderful increaſe of this inſect; which according to Dr. Richardſon conſiſts of ten generations, and of fifty at an average in each generation; ſo that the ſum of fifty multiplied

multiplied by fifty, and that product again multiplied by fifty nine times, would give the product of one egg only in countlefs millions; to which muft be added the innumerable eggs laid by the tenth generation for the renovation of their progeny in the enfuing fpring.

Their punctures of the leaves of peach and nectarine trees in the vernal months, and of cherry, plum, and currant trees in the fummer, produce a fwelling and elevation of the cuticle of the leaf on its upper fide, and a confequent curling of it with its upper furface outwards, which terminates in a deftruction of it to the great injury of the tree, and frequently to the death of it; while the leaves of the nut-trees, mentioned above, in No. 1. 7. of this Section, appeared to be but little injured by them, though fifty or a hundred of thefe infects were feen under every leaf about Midfummer, both before and after their affufion with the honey-dew.

From Dr. Richardfon's account the aphifes on the rofe-tree appeared in February, when the weather happened to be warm, from fmall black oval eggs; which were depofited on the laft year's fhoots in autumn; and that, when the weather became colder, great numbers of them perifhed, by which circumftance the rofe-trees are in fome years almoft freed from them.

They came to their full growth before April, and after having twice caft off their exuviæ, every one of them produced about fifty young ones; all of which came into the world backwards, and adhered fometime to the vent of the parent by their mouths or forepart; as fhewn in a magnified ftate at fig. 2. plate IX; and were at length fet down on fome tender fhoots of the plant, and came to maturity in about ten days, cafting off their coats two, three, or four times.

The ninth generation in October confifted of males as well as females, which were feen to cohabit; and the eggs produced by their intercourfe, he afferts, were depofited generally near the new buds, or on other parts of the twigs of the trees, which they poffeffed.

Thefe were at firft green, but in a few days became brown, and by degrees quite black. They were of regular oval figures about one tenth of an inch in length, and about half as broad, and adhered firmly by means of fomething glutinous, and refifted the feverity of the winter.

Other infects, which are produced from eggs, and become winged butterflies or moths, live for fome time in the intermediate ftate of caterpillars or larvæ. During this ftate of their exiftence they feed on the leaves, on which they are hatched; or on fruits or kernels; but after they have acquired wings and organs of reproduction, fome of them take no food, as the filkworm; and others live only upon honey, as bees, and moths, and butterflies. Now the aphis, I fuppofe, has no intermediate ftate between the egg and the fly, and therefore makes no holes in the leaves by eating them; or if any of them previoufly exift in a caterpillar, or larva ftate, it can be only thofe which are produced from eggs in the early fpring, which is worthy of future attention.

Whence I fuppofe, that this fly lives not by confuming the foliage of the plants, which it inhabits; but by piercing the pulmonary veffels in their natural ftate, or the lymphatic veffels of the leaf in their retrograde ftate, by a fine tube or probofcis, which it poffeffes, and which it may be feen by a common lens perpetually to employ, as fhewn under its chin in the magnified infect at figure firft of plate IX. For the fap-juice or vegetable chyle is brought from the radicles of each leaf-bud, and propelled up the long caudex to the pulmonary artery of the leaf, where it becomes oxygenated, and converted into vegetable blood. And may thus be extracted by the tubes of thefe infects before its fanguification.

Perhaps thofe aphifes, which were from eggs, might eat fome part of the peach leaves during their larva ftate, if fuch exifts, and occafion them to curl up. While thofe, which were a viviparous progeny, might only pierce the fap-veffels, or blood veffels, and thus not ap-

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parently injure the leaves; as on the nut-trees, where perhaps they were not hatched from eggs, but might have come thither in their winged ſtate, and have then produced their innumerable viviparous offspring; as on the nut-trees above mentioned I could not diſcern the eggs, from which they were hatched, and a few larger aphiſes with wings appeared early in the ſeaſon amongſt the ſmaller ones without wings.

We may finally conjecture on this intereſting ſubject, firſt, that the aphiſes produced from eggs early in the ſpring may have a larva or caterpillar ſtate, and that during that ſtate they may feed on the young leaves of peaches, nectarines, plums, and cherries, and thus occaſion them to curl and die. 2. That thoſe, which are not from eggs, have no larva ſtate, and only puncture the larger chyle veſſels of the young twigs, or the pulmonary arteries of the leaves, which receive the vegetable ſap-juice from the roots, and thus that they ſuck it up, and live on it, before it is converted into blood, as moths, butterflies, and bees, live on honey in their winged ſtate, though on other parts of vegetables, as on their leaves, or anther-duſt, in their larva ſtate; and that theſe punctures are attended with no viſible injury to the leaf. 3. That for a week or two about Midſummer, when the umbilical veſſels of the new buds convey the ſap-juice to them, or to the reſervoirs of nutriment preparing for them, that the aphiſes by piercing theſe veſſels, or the pulmonary arteries of the leaves, acquire ſo large a quantity of this ſaccharine material, that it paſſes through them almoſt unchanged, falling on the leaves and ground beneath them, and produces what is called the honey-dew; but that this happens only for a ſhort ſeaſon, as a week or two about Midſummer, during the production of the new buds. And laſtly, that the black powdery material on the upper ſurface of the leaves of the nut-trees and plum-trees, and of the ſhrubs which grow beneath them, is an excrement from the aphiſes, which hang on the under ſurfaces of the leaves above them, like the black bitter powder in the

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nut-ſhell; which is the excrement of the curculio, which has eaten the ſweet kernel.

Secondly, having laſt year written the above, I have had another opportunity of attending to the aphis during the ſummer of 1799, and ſhall add the further remarks, which I have been able to make on this moſt curious and important animal, which may in proceſs of time deſtroy the vegetable world.

As the month of June was again in this ſummer very dry, though not very warm, the aphis was propagated in immenſe numbers on a great variety of trees, ſhrubs, and herbaceous plants. The row of nut-trees mentioned in No. 1. 7. of this Section was infeſted with a greater number of them this year than in the preceding one; yet during the ſeaſon about Midſummer there was ſo little honey-dew this year, that it might have eſcaped obſervation, if it had not been particularly attended to; yet what did appear was only on the upper ſurfaces of thoſe leaves, which had other leaves impending over them crowded with aphiſes; whence I had no doubt, but that it was voided by the millions of aphiſes, which adhered on the under ſurfaces of thoſe ſuperior leaves with their backs downwards.

On examining them with a ſtrong magnifier I could frequently perceive them inſert their proboſcis or trunk into the veſſels of the inferior ſurface of the leaf; and particularly obſerved, that when they were not moving from place to place, that they generally ſtood with their heads towards the foot-ſtalk of the leaf of nut-trees, or towards the baſe of the twigs of plum-trees, which circumſtance I ſhewed to many of my friends.

Both before and after the exiſtence of the honey-dew a black material, which was ſometimes moiſt and ſometimes dry, appeared on the upper ſurfaces of thoſe leaves only, which had other leaves crowded with aphiſes over them, and even on the upper ſurface of the leaves of ſome herbaceous plants, which grew under theſe nut-trees, and alſo on others, which grew under plum-trees, which were much infeſted with an aphis of a greener colour.

To prove beyond poſſibility of error that this black matter was dejected on the leaves below by the aphiſes, which were walking with their heads downwards on thoſe above, I ſewed ſlightly with a needle and thread under ſeveral leaves a piece of writing paper about the ſize of the leaf; and obſerved on the next day that many black marks were diſtinguiſhable on the paper.

On plum-trees and on many herbaceous plants innumerable aphiſes were ſeen on the upper tender part of the upright ſhoots, adhering with their heads downwards; and on the hanging ſhoots with their heads upwards; and inſerting their proboſcis into the veſſels, I ſuppoſe, which contained the aſcending ſap-juice. But on the nut-trees the moſt tender or uppermoſt parts of the young ſhoots were covered with very numerous briſtles, which appeared to be an armour purpoſely produced to defend them from theſe deſtructive inſects, and hence they were principally found on the under ſurfaces of the leaves.

As the chyle of animals is mixed with the venous blood, and is immediately projected by the force of the heart into the pulmonary artery, at the extremities of which it is principally converted into blood by its expoſure to the air; ſo in the vegetable ſyſtem the ſap-juice muſt be mixed with the returning venous blood, and carried forwards to the extremities of the pulmonary artery of the leaf, before it is converted into vegetable blood. Theſe pulmonary arteries paſs along the under ſurfaces of leaves, as the upper ſurfaces of them are covered by the fine terminations of them on an air-membrane for the purpoſe of reſpiration; hence on theſe under ſurfaces of leaves the aphiſes adhere, and pierce the branches of the pulmonary arteries with their proboſcis ſtanding with their heads towards the ſtalk of the leaf, that they may thus meet the ſtreams of chyle or ſap-juice yet unchanged into

into blood; which accounts both for their exiſting in all kinds of weather on the inferior ſide of the leaves, and for their ſtanding with their heads towards the foot-ſtalks of them. Thus on an upright twig of a plum-tree I this day obſerved a number of aphiſes adhere with their heads downwards with their proboſciſes inſerted into the tender ſtem, and ſo near to each other, that the tail part of the lower ones extended one third of their length over the head part of thoſe above them, and gave ſomewhat the appearance of ſcales; while on the hanging twigs they adhered with their heads upwards, ſtill intent to meet the ſtreams of ſap-juice in the aſcending chyle veſſels, or in the pulmonary arteries.

Dr. Bradley and others obſerve, that about Midſummer there appears to be a pauſe in vegetation, and that at this time the new buds are generated; and Duhamel and others found, that the bark of ſeveral trees became at this time as eaſily to be ſeparated from the alburnum as in the ſpring; as is related in Sect. III. 2. 8. of this work. At this time therefore there exiſts a new flow of ſap-juice to ſupply preſent nutriment, or to furniſh a reſervoir of future nutriment to the newly generated or expected embryon, either before or after its vivification, or its impregnation, if ſuch a proceſs may be ſuppoſed to occur in the production of buds.

At this time then, when there exiſts a ſummer-flow of ſap-juice, this pernicious inſect in uncounted millions pierces the ſap-veſſels round the new ſhoots, or the pulmonary arteries beneath the leaves; and thus drinks the vegetable chyle, or ſap-juice, with ſuch avidity, as to part with much of it again almoſt unchanged. This I now believe with Sauvage to be the origin of one kind of honey-dew certainly; and if another kind of honey-dew exiſts, as he mentions, where there are no aphiſes, I ſuſpect, as obſerved in No. 1. 7. of this Section, that it muſt ariſe from the inverted action of the lymphatic veſſels of the leaf, at the time of the increaſed quantity of ſap-juice about Midfummer; but have not had an opportunity to afcertain thefe facts.

Thirdly. There appears to be a power impreffed on organized bodies by the great author of all things, by which they not only increafe in fize and ftrength from their embryon ftate to their maturity, and occafionally cure their accidental difeafes, and repair their accidental injuries, but alfo a power of producing armour to prevent thofe more violent injuries, which would otherwife deftroy them. Of this laft kind are the poifonous juices of fome plants, as of atropa belladonna, deadly nightfhade, hyofcyamus, hen-bane, cynogloffum, hounds-tongue. Other plants are armed with thorns and prickles to prevent the depredation of animals, as ilex, holly, cratægus, hawthorn, ribes groffularia, goofeberry; the leaves of which would be perpetually devoured but for this kind of protection. Other plants fecrete a vifcid juice to agglutinate the infects, which crawl up towards their fructification, as filene, catchfly, drofera, fun-dew; and others by the contraction of their leaves or petals arreft or deftroy the infects, which attack them, as dionœa mufcipula, and apocynum androfemifolium.

But how can vegetables protect the whole inferior furfaces of their leaves, and of their young rifing ftems from the innumerable progeny of the deftructive aphis, which penetrates their chyle veffels and their arteries; and which from their immenfe numbers may in procefs of time deftroy the vegetable world. Many vegetables have not yet acquired any means of defence, and have therefore the firft growth of their foliage much injured, or totally deftroyed by this deftructive infect, as the nectarine, and peach, and plum, and cherry-trees, in many parts of this country, as is every year feen and lamented.

Some vegetables have neverthelefs already acquired an armour, which leffens, though it does not totally prevent, the injuries of this animal. This is moft confpicuous on the ftems and floral-leaves of mofs-moſs-roſes, and on the young ſhoots and leaf-ſtalks of nut-trees. Both theſe are covered with thickſet briſtles, which terminate in globular heads, and not only prevent the aphis from ſurrounding them in ſuch great numbers, and from piercing their veſſels ſo eaſily, but alſo ſecrete from the gland, with which I ſuſpect them to be terminated, a juice; which is inconvenient, or deleterious to the inſect, which touches it.

Hence moſs-roſes appear to be leſs injured by the aphis, than other roſes, which have leſs of this armour; and while on plum-trees, and on many herbaceous plants, they hang round the upright young ſhoots with their heads downwards, and inſert their trunks, ſo as totally to conceal the riſing ſhoot; yet on nut-trees, though they are ſeen in millions beneath the leaves on the unarmed parts, they never appear round the young ſhoots, nor on the large trunks of the veſſels beneath the leaves, all which have acquired a panoply of briſtles with glandular heads to them, like thoſe round the moſs-roſe, but without the branching ſtructure of the latter. While thoſe plants, which are not infeſted with the legions of this ſelf-productive animal, have probably acquired ſome material mixed with their ſap-juice, or blood, which is poiſonous to them; as thoſe plants, which poſſeſs a milky or a yellow blood, as the ſpurges euphorbia, or the celandines chelidonium, or the fig-tree, ficus.

Nor is this more aſtoniſhing, than that the holly-trees ſhould annually ſupply prickles only to their lower leaves, about ſix or eight feet from the ground, as high as the animals can reach them, which would prey upon them; but refuſe the expence of putting forth prickles in their higher branches, which are ſaved by their ſituation, as I have repeatedly obſerved on the numerous holly-trees, which are the ornament of Needwood foreſt.

From hence I ſuſpect, that another reaſon, why the leaves of nut-trees and of roſe-trees are not curled up or bliſtered like thoſe of nectarines, peaches, plums, and cherries, is becauſe their foot-ſtalks,

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and the larger branches of the pulmonary arteries, are defended by thefe briftles, which are perhaps only beginning to appear on the leaf-ftalks of the plum, but which may increafe in the progreffion of time; as all the works of nature may be approaching to greater perfection, as mentioned more at large in No. 2. of the laft Section of this work.

Fourthly. The means of deftroying an infect fo extenfively injurious not only to gardens and hot-houfes, but to half the vegetable world, would be indeed a valuable difcovery. If the eggs exift on the young buds, as Dr. Richardfon affirms, fome application to thefe, before they are hatched, which might diffolve their fhells, as by very dilute marine acid injected on them; or by fome adhefive material, which might invifcate them as foon as they are hatched, whether they appear firft in their larva ftate, like minute caterpillars, or in the form of the parent aphis, as foap-fuds injected on the twigs before the leaves begin to unfold; or perhaps by rubbing them with oil or glue by means of a fponge, or a painter's brufh; but experiments alone can determine the effect of thefe applications, both on the infect and on the tree.

Lime water alone will not readily deftroy the aphis, as I obferved by immerfing leaves with aphifes on them; which crept up the leaves, and thus efcaped. But if pot-afh, or fixed alkali, be mixed with lime, the folution becomes fo cauftic as to deftroy many infects without injuring the foliage of trees, or the ftems of wheat, if we may credit M. Socoloff, who in the tranfactions of an Academy at Peterfburgh, Vol.V. afferts, that he added three parts of quick-lime newly made to two parts of a faturated folution of fixed alkali in water; which poured on the ground deftroyed the earth-worms, and fprinkled on the leaves of trees deftroyed the caterpillars, but did not injure, or much injure the foliage of trees, or the leaves of wheat plants.

Tar water has lately been faid to deftroy flugs, white fnails without

out ſhells, and might be worthy a trial by injecting it on trees at firſt with caution, leſt it ſhould injure them; as it is probably the vegetable acid chiefly, with a ſmall portion of eſſential oil, which is diſſolved, or mixed with the water, by agitation. See No. 3. 5. of this Section.

Previous to the pullulation of the buds, it is alſo believed to be of great ſervice to water wall-trees with lime-water, or with ſoap-ſuds, or perhaps with the addition of ſome pot-aſh to either of them to make a more cauſtic ley, ſuch as is recommended for ſteeping ſeed-wheat; but this with caution, as I have known a ſolution of hepar ſulphuris kill the branches of a tree, which were moiſtened with it, as well as the inſects, which were upon it. Nor am I certain that this will anſwer the purpoſe from the obſervations I have heard from thoſe, who have tried it.

The eſſential oils are all deleterious to certain inſects, and hence their uſe in the vegetable economy, being produced in flowers or leaves to protect them from the depredations of their voracious enemies. One of the eſſential oils, that of turpentine, is recommended by M. de Thoſſe for the purpoſe of deſtroying inſects, which infect both vegetables and animals. Having obſerved that the trees were attacked by multitudes of ſmall inſects of different colours (pucins ou pucerons), which injured their young branches, he deſtroyed them all entirely in the following manner. He put into a bowl a few handfuls of earth, on which he poured a ſmall quantity of oil of turpentine; he then beat the whole together with a ſpatula, pouring on it water, till it became of the conſiſtence of ſoup; with this mixture he moiſtened the ends of the branches, and both the inſects and their eggs were deſtroyed, and other inſects kept aloof by the ſcent of the turpentine. He adds, that he deſtroyed the fleas of his puppies by once bathing them in warm water impregnated with oil of turpentine. Mem. d'Agriculture, An. 1787, Printemp. p. 109.

I ſprinkled ſome oil of turpentine by means of a bruſh on ſome

 branches

branches of a nectarine-tree, which was covered with the aphis; but it killed both the insect and the branches. A solution of arsenic much diluted did the same. Might not the scent of turpentine, or of tar, smeared on a fruit-wall deter the flies from approaching the trees to deposit their eggs? or might not arsenic mixed with honey be smeared on the wall, to which the trees are nailed, be likely to attract the aphis as well as other kinds of flying insects. But none of these should be smeared on the branches, lest it injure or destroy the tree. Perhaps if a few twigs smeared with turpentine, mixed with a little oil of turpentine to make it more fluid, and to increase its odour, were fixed in quince-trees, or in apple-trees, the flowers of which are liable to be destroyed by the eggs deposited in them by a small fly; they might be deterred from approaching the tree, as the great use of essential oils, which cause the fragrance of flowers, seems to be to deter insects from infesting their leaves, or preying upon their honey.

It is probable, that if infusions were made in hot water, or perhaps for a longer time in cold water, of those leaves which no insects devour; as of the walnut, juglans; lauro-cerasus, laurel; foxglove, digitalis; hen-bane, hyoscyamus; hounds-tongue, cynoglossum; rag-wort, senecio jacobæa; or of tobacco, nicotiana; and many others; and were sprinkled on the curled leaves of wall-trees, or on the buds before they open, by a pump, or by a brush, or sponge; they might destroy the insects without injuring the trees, which might be determined by a few experiments.

The dust of tobacco is frequently spread on affected leaves, but not I believe with very encouraging success, owing perhaps to the powder not being very fine, or not soon enough applied. Some kinds of lime strewed on in powder might probably be too caustic, and destroy the leaf along with the insects; which also might be subjected to experiment. The powder of sulphur, or of tobacco, or of any of the poisonous leaves above mentioned, might be injected upon affected trees

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by a powder-puff, ſuch as hair-dreſſers uſe, or the ſmoke of tobacco, or of any other of the poiſonous leaves above mentioned, might be forcibly blown on them by an adapted pair of bellows, as the ſmoke of many of them may poſſeſs as poiſonous a quality as that of tobacco; and even the ſteam of a decoction of others, as of lauro-ceraſus, and walnut; the poiſon of the former of which is known to riſe in diſtillation, might probably be uſed with effect; but this muſt depend on the greater or leſs fixity of their eſſential oils. The ſmoke or ſteam might be applied to wall-trees by previouſly ſuſpending over them a large ſheet of matting, or of linen, or of paper, or an old carpet; but may however be uſed with greater advantage in hot-houſes, than in the open air.

Since the above was written I directed in the early ſpring of this year one nectarine-tree to be moiſtened with tar-water, and parts of the wall to be ſmeared with tar; another to be moiſtened with lime and pot-aſh diſſolved in water; a third with ſoap-ſuds and lime added to them; and many both nectarine and peach-trees with ſoap-ſuds alone. This was done by means of a bruſh before any flowers appeared, and was repeated thrice on different days; but to my great diſappointment, when the leaves appeared, they became affected with the aphis as on former years. I alſo afterwards dipped many nut-leaves crowded with the aphis in ſtrong infuſion of tobacco, for a few minutes, as the leaves hung on the trees without, as I believed, deſtroying the inſects; though ſome of them appeared for a time to be rendered torpid.

Nevertheleſs on covering a low nut-tree with ſome ſheets of brown paper ſewed together, and throwing the ſmoke of tobacco under it from a proper pair of bellows, great numbers of aphiſes were killed, many of which dropped from the upper leaves on thoſe below them, and many adhered motionleſs to the under ſurfaces of the leaves. The fine powder of tobacco called Scotch ſnuff ſprinkled on the aphiſes by turning up ſome of the leaves quickly deſtroyed them.

As walnut-leaves may be had in great quantity in the autumn, and the whole plant of fenecio jacobæa, rag-wort, at any time, both which are probably deleterious to infects, as they feem never to be injured by them, thefe might be procured at fmall expence, and might probably, when dried and burnt, produce a fmoke equally deftructive to them.

Fifthly. The moft ingenious manner of deftroying the aphis would be effected by the propagation of its greateft enemy, the larva of the aphidivorous fly; of which I have given a print, and which is faid by Reaumeur, Tom. III. Mem. 9. to depofit its eggs, where the aphis abounds; and that, as foon as the larvæ are produced, they devour hundreds around them with the neceffity of no other movements but by turning to the right or left, arrefting the aphis and fucking its juices. If thefe eggs could be collected and carefully preferved during the winter, and properly difpofed on nectarine and peach-trees in the early fpring, or protected from injury in hot-houfes; it is probable, that this plague of the aphis might be counteracted by the natural means of devouring one infect by another; as the ferpent of Mofes devoured thofe of the magicians.

Mr. Horrocks of Derby fhewed me this larva of the aphidivorous fly, which I faw devour two or three aphifes, and Mr. Swanwick of this town at my requeft made an accurate drawing both of the larva and fly, which he kindly favoured me with, accompanied with the following note.

"On Auguft the 4th Mr. Horrocks obligingly fent me an aphidivorous larva in a box on a leaf of a plum-tree, on which were a number of aphifes; and I had almoft immediately the pleafure of feeing it eat one.

"The method of taking his prey is thus: he is like the floth in his difpofition, for he does not ramble about, while he has food around him. He only lifts up his head, and ftrikes it down again, extending it in various directions, as if he was blind, and repeating the above ac-

 tion.

tion. If by ſo doing he happens to feel an aphis, he immediately ſeizes it by the back, lifts it up and poiſes it in the air, as if to prevent it from liberating itſelf by its ſtruggles againſt the ſurface of the leaf, or that it may fall more eaſily into the cavity of his mouth. In this poſition he holds it, while he pierces it, and ſucks the juice out of the body; which having done, he drops the ſkin, licks his lips round with his little black tongue, contracts his head, and drops it down; thus reſting in perfect repoſe for ſome time, after which he repeats the ſame actions. But if he is in the midſt of plenty, he ſeldom gives himſelf this trouble, but waits till an aphis touches him, when he immediately turns his head round, and with fatal certainty ſeizes him, poizing him as before.

"For the purpoſe of ſeeing what fly was produced from this caterpillar, I procured him food for about ten days. During this time he eat a great number of aphiſes, and grew to about an inch in length; when he left off eating, contracted himſelf to about half his former length, fixed himſelf to the box by a little gluten, which he diſcharged from his mouth, and without caſting a ſkin changed to a chryſalis.

"In this ſtate he lay about ten or eleven days, at the end of which time he burſt his cell, and came out a beautiful fly, of which the figure is a good repreſentation."

No. 1. The caterpillar with an aphis in his mouth.

No. 2. The chryſalis open at one end.

No. 3. The fly.

Another enemy to the aphis is ſaid to be a beautiful ſmall ſpotted beetle, called a lady-bird by the people. Several of theſe were ſeen on the nut-leaves, and are believed firſt to appear there in their larva ſtate, and to feed on the aphis; they then change to a chryſalis, and laſtly to a ſmall wing-ſheathed beetle; and finally, I ſuppoſe, they bore holes into the earth, as would appear from their poſſeſſing ſheaths to their wings, and that they there depoſit their eggs to be hatched;

hatched, and to climb the trees infefted with the aphis in the enfuing fpring.

Thus from the exertions of a few aphidivorous larvæ or caterpillars, from the poifonous juices of fome plants, and from the briftly armour on the young twigs and leaves of others, the vegetable world is fo far protected from the deftruction, with which it has been, and is threatened, by the fine probofcis of this multitudinous infect, which in its manner of attack refembles that of the large bat of Afia, vefpertilio-vampyris; which is afferted by Linneus to drink the blood by night of fervants, who fleep in the open air, Syft. Natur. p. 46; and is faid by others to be fo fkilful an operator as not to wake the patient by the puncture, which it inflicts, as it agreeably fans them with its wings.

3. Many of the orchards of apple-trees in this country are liable to lofe all their leaves by the depredations of caterpillars; the fame occurs to goofeberry-trees in fome gardens, and to cabbages in the latter part of the fummer.

A few years ago I obferved, that the bloffoms of the quince-tree, before they were quite expended, were perforated by a fly; as the wound could be eafily difcerned like that on young nuts, when wounded by the curculio; and all the bloffoms of a large tree were thus deftroyed by a fmall caterpillar. And in this late fummer of 1799 the apple-bloffoms in this country are much injured by a caterpillar, which eats the feed in the pericarp of each bloffom either before or at the time of its impregnation, the petals of the flower clofing again over it and dying.

The leaves of many trees are renewed after having been totally deftroyed in the early part of the feafon; as thofe of the apple-tree above mentioned, which had loft its leaves entirely by lightning; as the mulberry-trees in Italy, which are thus robbed of their firft leaves to feed filk-worms, as the tea-tree in China, which is thus robbed for a fafhionable potation. And laftly, as the euonymus, or fpindle-tree, which

which in this country has its firft crop of leaves almoft perpetually deftroyed by caterpillars. But though the leaves are reftored after the depredation of this infect, yet there follows an irremediable injury to the fruit. See Sect. IX. 2, 6.

As the eggs of butterflies are in the autumn wifely depofited in fituations, where the young can find proper food, when they are hatched by the warmth of the fpring; thofe on apple-trees, and on goofeberry-trees, are frequently depofited on the leaves, as well as on other parts of the tree; and as thefe leaves fall on the ground, the eggs are thus covered and protected from the frofts, and the young caterpillars are believed to climb the trees in fearch of their food. If this be true, it would be an advantageous practice to rake together the leaves in orchards, and to burn them; which fome have done from an idea, that the fmoke thus produced was noxious to the eggs of infects depofited on the branches.

Some gardeners for this purpofe rear their goofeberry trees on one ftem only; and believe, that by tying a fringe round this ftem the infects, which are hatched in the foil, if fuch there be, can not climb up the tree thus furrounded with a fringe; and as thofe caterpillars, which are already on the tree, let themfelves down by a thread, when the tree is fhaken, from the fear of being hurt by the vibrating twigs; if this thread be then broken, by moving a ftick round under the tree, thefe infects cannot reafcend. A paper recently tarred on the outfide might be wrapped round the ftem of the tree inftead of the fringe with perhaps more certain fuccefs; but the tar fhould not be fmeared on the bark of the tree, left it fhould injure or deftroy it.

It may be obferved in the choice of apple-trees, that thofe kinds, which flower early, are lefs liable to the depredation of infects; and thofe, which flower late, are lefs liable to the injuries of froft. In apple-trees perhaps the former is in fome fituation the greater evil, but in pears I fhould fufpect the latter, the bloffoms of which are fo often totally deftroyed by one night's froft.

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The white butterflies, which depofit their eggs on cabbage plants, are feen flying about awkwardly in fummer, and fhould be caught, and deftroyed by the gardener. Or they perhaps might be invited and poifoned by a mixture of honey, and water, and arfenic; as a wealthy man in Italy was faid to have poifoned his neighbour's bees. See Sect. VI. 6. 3. Thefe cabbage-caterpillars would increafe in deftructive numbers, but are half of them annually deftroyed by a fmall ichneumon fly; which depofits its own eggs in their backs, which are there hatched by the warmth of the animal, and live on the filk there fecreted for its future neft; and eroding their way out fpin fmall cacoons of their own; ten or twelve of which hang on each caterpillar; which thus perifhes inftead of changing into a butterfly. This I faw happen to a great many of them, which were put into a box on bran with a few cabbage leaves, and covered with gauze, a few days before they were ready to change into chryfolifts. This ichneuman fly fhould therefore be encouraged, if his winter habitation could be difcovered.

4. The variety of infects, which infeft hot-houfes, as the acarus, thrips, aphis, and cocci, and the means commonly ufed to deftroy them by the fmoke of tobacco, or by the powder of fulphur and tobacco, or by folutions of lime and fulphur, are defcribed in Speechly's books on the Vine and Pine; but require fome caution in their application. A friend of mine, by fubjecting a wall-tree to the fmoke of fulphur by hanging a matt before it during the fumigation, killed both the infects and the tree.

5. Other kinds of infects are produced beneath the foil, or occafionally retire into terreftrial habitations. Of thefe are the various families of fnails, with and without fhells, and other infects with fheaths over their wings, with which they are furnifhed to prevent any injury from the friction of the fides of the holes they make or defcend into.

It has been lately fuppofed, that the great deftruction of the crops of of turnips, which occaſionally occurs, is owing to the depredation of a white ſlug, or ſnail, which comes out of the ſoil before ſun-riſe in dewy mornings; and that by rolling the young turnips with a heavy roller before ſun-riſe for a few mornings, theſe pernicious inſects may be deſtroyed, and add manure to the riſing plants they have injured.

The white ſlugs in gardens are very deſtructive to many flower-ſtems, as they riſe out of the ground, as to dictamnus fraxinella, apocynum androſemifolium, to phaſeolus, kidney-bean, to cinara, artichoke, and many other plants. I well remember in one ſeaſon favourable to their production in a garden by the ſide of the Derwent obſerving, that many artichoke ſtems above a foot high were eaten by them near the moiſt earth till they fell down, like trees felled by the ax. It has lately been aſſerted, that watering the ground with tar-water will deſtroy them; which may be made by adding a few pounds of tar to a hogſhead of water, and well ſtirring it, without perceptible injury to the tar. A circle of lime round the flower-ſtems, or of ſalt, or even of bran in dry weather, are means of preventing the approach of ſlugs; and ſome gardeners lay a board lightly on the ground between the alleys, under which the ſlugs hide themſelves when the ſun riſes, and are hence eaſily caught and deſtroyed.

The leaves of the young turnip are alſo believed to be deſtroyed by a fly; which, if it be of the ſcarabæus, or beetle kind, which ariſes out of the earth, may likewiſe be deſtroyed by rolling. The Chineſe are ſaid by ſir G. Staunton to ſteep all their ſeeds in liquid manure until they ſwell, and their germination begins to appear; which they believe not only haſtens the growth of the plants, but alſo defends them againſt inſects beneath the ſoil; and that to this ſir George obſerves it may be owing, that the Chineſe turnips eſcape the fly ſo injurious to them in this country. Embaſſy to China, 8vo edit. Vol. III. p. 310. An obſervation of Mr. Guillet in the Bath Agriculture, Vol. II. Art. 44, ſeems to confirm this idea. He aſſerts, that when turnip ſeed is ſown during rain, or has rain immediately afterwards, that the firſt leaves are ſo vigorous that the fly never attacks them; or that the rain itſelf is ſo inconvenient to the fly, as to prevent its appearance. It is alſo aſſerted by Mr. Exeter in the Tranſactions of the London Society for Arts, Vol. XVI. p. 191, that the ſowing turnips in drills deeper than by broad caſt, accelerates the growth of the plant by giving it more moiſture; whence it ſooner puts forth its rough leaves, and eſcapes the depredations of the fly. He ſpeaks highly of the uſe of the drill, adviſes the rows to be one foot diſtant, uſes three quarters of a pound of ſeed to an acre, and ſows them from one inch and a half to two inches deep.

6. The great numbers and varieties of animated beings, which live under the ſoil, and ſleep in winter, deſcending beneath the reach of froſt, is truly aſtoniſhing. I once obſerved ſuch immenſe numbers of ſmall wing-ſheathed inſects, which I believed to be the ſcarabæus ſolſtitialis, or fern-chaffer, as they were not one ſixth part of the ſize of a May-chaffer, ſcarabæus melolontha, though much of the ſame form and colour; which aroſe out of the ground near the cold bath at Lichfield, that I gueſſed, that one or two emerged from every ſquare inch of many acres of land.

The grubs or maggots, from which theſe wing-ſheathed flies aroſe, I ſuſpect in ſome ſeaſons and ſituations favourable to their production to be very deſtructive to the wheat in ſpring, or the early part of ſummer, devouring the ſtem near the ſurface of the ground at the joint, which is ſweet, till it falls down or withers, by which many crops were nearly deſtroyed this year, 1797, and that, I was informed, on ſome lands, which had been previouſly well limed.

Mr. Tull in his huſbandry, ſpeaking of wheat, adviſes not to ſow it deeper than an inch, ſince the thread or caudex, which connects the lower or ſeminal root with the upper or coronal root, he believes to be then not ſo readily found by worms in the winter, as one three inches long might be, both on account of the greater length of the

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latter, and becaufe infects do not rife fo near the furface in the winter months.

Where this peftilential grub occurs, perhaps rolling the land early in the mornings in the fpring might crufh them. And when the fly is feen to come out in fuch abundance in the fummer evenings on grafs land or fallows, it is probable, that rolling the ground in the evening might prevent the return into the earth both of thefe and of the May-chaffers to depofit their eggs, and thus prevent their future progeny; or during their grub ftate, when they exift at the roots of wheat above or juft beneath the furface of the foil, perhaps flaked lime might be fprinkled over the crop in powder, or fea-falt in powder, which might be wafhed down the ftems of the corn in a wet day, and deftroy the infect without injuring the vegetable; or laftly, by tar-water; all which might be firft tried on a fmall part of a field; for as lime is not all of equal purity, it is not all of the fame ftrength or caufticity.

Another infect is faid to injure wheat when in flower, and is fuppofed to be the thrips phyfapus of Linneus, as mentioned in the tranfactions of the Linnean Society, Vol. III. But as it only attacks the late flowering ftems, it may poffibly be prevented by fowing the wheat early, if it fhould ever become a ferious evil.

Some time ago an infect called a corn-butterfly committed great ravages in France while in its vermicular ftate, fo as to ruin two hundred parifhes. A cure for it was at length difcovered, which confifted in drying the wheat in an oven before fowing it, and thus expofing it to fuch a degree of heat as would deftroy the eggs of the infect without injuring the feed; or perhaps which hatched them without fufficient moifture to foften the grain for their fupport. See Encycl. Britan. Agricult.

Between Chefterfield and Plaifly in Derbyfhire I well remember above forty years ago to have feen for two or three miles together every leaf of the hedges devoured by the May-chaffers, fcarabæus

 melolontha,

melolontha, which hung on each other, where the foliage was deſtroyed, like bees in a ſwarm. And to have found in the ſame year, as it lay dead in a field near Cheſterfield, a true locuſt, like a very large graſs-hopper with very long and broad wings; which I preſerved in ſpirits, and was informed, that many of them were found in other parts of England about the ſame time.

All theſe noxious animals might be deſtroyed or diminiſhed by encouraging the breed of ſmall hedge-birds, and perhaps of larks, and of rooks, by not taking their neſts. I have obſerved, that houſe ſparrows deſtroy the May-chaffer, eating out the central part of it; and am told that turkeys and rooks do the ſame; which I thence conclude might be as grateful food, if properly cooked, as the locuſts or termites of the eaſt. And probably the large grub, or larva of it, which the rooks pick up in following the plow, is as delicious as the grub called groogroo, and a large caterpillar, which feeds on the palm; both of which are roaſted and eaten in the Weſt Indies. The various ſpecies of linnets carry ſmall caterpillars to their gaping young; and hedgehogs are ſaid to devour ſnails, and on that account to be profitably kept in gardens.

When a ſevere froſt occurs, before the ground is covered with ſnow, thoſe inſects, which do not penetrate deeply into the earth during their hybernation, as the ſhell-leſs ſnails or ſlugs, are liable to be deſtroyed, and probably many of the larvæ of the fern-chaffer and May-chaffer, as is ſeen by their diminiſhed numbers in the enſuing ſeaſon.

In China the aurelia of the ſilk-worm, after the ſilk is wound off, and the white earth-grub, and the larva of the ſphinx moth, furniſh articles at the table, and are ſaid to be delicious. Embaſſy to China. Neverthele ſs all the caterpillar tribes may not be equally innocuous; as in this climate the hairy caterpillars, if laid between the fingers, where the ſkin is tender, I have obſerved to produce an itching, and leave ſome of their pointed briſtles in the ſkin. And M. Vaillant,

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in his travels in Africa from the Cape, aſſerts, that both a black and a white hairy caterpillar becomes ſo poiſonous, when it feeds on a large euphorbia, that the natives put them in bags, bruiſe them, and after a few days poiſon their arrows with them. But that they are leſs poiſonous if they feed on leſs acrid vegetables.

There muſt be great difficulty in deſtroying the larvæ, or grubs, or caterpillars, of many inſects, which are injurious to the fruits and kernels, as well as to the foliage of plants, by any chemical mixtures; as in this ſtate, I ſuppoſe, ſome of them are uncommonly hardy or tenacious of life. Mr. Gouch affirms, that he kept the curculio nucum, or worm found in nuts, in brandy for ſeventeen hours, which recovered; and I remember putting a worm, which came from a perſon, who called it an aſcaris, though it was above an inch long, and nearly as thick as a thin crow-quill, into a ſaturated ſolution of ſugar of lead in water; which lived many hours without apparent injury. See Nicholſon's Journal, No. 21, for November 1798.

7. A great number of bees, as well as of moths, and butterflies, muſt be very injurious to flowers, and conſequently to the production of fruits, as all of them plunder the nectaries of their honey, and thence deprive the anthers and ſtigmas of their adapted nouriſhment, as mentioned in Sect. VI. 6. 3. This would be more deſtructive to the ſeminal products of plants, but that many of them poſſeſs means of defending their reſervoirs of honey, and yet of expoſing it to the influence of the air, ſome of them by long winding canals, as in the bottom of the tubes of the honey-ſuckles, trefoils, and larkſpurs, lonicera, trifolium, delphinium; others by covering it with a hood, as in monkſhood, aconitum; others by a gluten, as in catchfly, ſilene, and in ſun-dew, droſera; others by contracting ſome part of their leaves or flowers, and deſtroying the hoſtile inſect, as in dionœa muſcipula, and in apocynum androſemifolium; and finally, many other flowers have probably acquired the habit of ſecreting more ho-

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ney than is neceſſary for their own conſumption, as cacalia ſuaveolens, alpine colts-foot, and polygonum fagopyrum, buck-wheat. From all theſe contrivances the flowers of plants probably receive leſs injury from the depredations of bees, moths, and butterflies, in this country, and from the humming bird in tropical climates, than they otherwiſe would be ſubject to.

But beſides the loſs of much of their honey an abundance of bees muſt likewiſe injure the ſeminal products of vegetables by plundering the ſtamina of flowers of their anther-duſt for bee-bread, as Mr. Hunter believes; and alſo of the wax, which covers the anthers for their defence againſt rain. Nevertheleſs, as mankind convert to their own purpoſes the honey thus collected by bees, and the wax, with which they fabricate their combs; and as the ſeeds of plants and their fruits are nevertheleſs in ſufficient abundance; the depredations of bees are not counteracted like thoſe of other inſects, but on the contrary encouraged.

The following obſervations, which I made this ſummer, may be of ſervice to thoſe who keep bees, and which I ſhall therefore here relate. The bees of one ſociety frequently attack thoſe of another ſociety, plunder them of their honey, and deſtroy moſt of them, perhaps all of them, in battle; in this reſpect reſembling the ſocieties of mankind! This war for plunder occurs more frequently than is commonly ſuſpected. Laſt year I had one hive of bees totally deſtroyed, and the year before another, which I did not take means to prevent, though I ſaw the conteſt, and the number deſtroyed in the latter; but not early enough in the commencement of hoſtilities.

Laſt week, June 16, I happened to ſee a great number of bees on the wing near the mouth of my only hive, and ſuppoſed that they were about to ſwarm. In an hour or two, on again attending to them I diſtinctly ſaw it was a violent battle; and at night obſerved about a hundred dead bees on the ground, and on the bench before the hive. I then directed a board about an inch thick to be laid on the

the bee-bench, and fet the hive on this board with its mouth exactly on the edge of this board, the mouth of the hive was alfo contracted to about an inch in length, and a femicircular hollow was made in the board immediately under the mouth of the hive. By this means the affailing bees were obliged to alight on the bee-bench, and then to climb perpendicularly up the edge of the board, on which the hive was now placed; and thus appeared to act with great difadvantage; and a much lefs number of bees appeared to be flain in this day's battle; whence it would be advantageous always to place bee-hives in this manner.

Neverthelefs, as the war did not ceafe, I directed early on the next morning to remove the bee-hive to a diftant part of the garden, and to a more eafterly afpect, and found to my great fatisfaction, that the hofts of the enemy did not follow; and that in a few hours the unaffailed bees refumed their work, as appeared by their going into the hive with loaded thighs; and though a few of them were feen on the following two nights refting on their old habitation, thefe were carried early on the enfuing morning in their torpid ftate to their new fituation, and the war ended without extermination of either fociety.

IV. DESTRUCTION BY VERMIN.

1. The deftruction of grain, after it is fown, by the field-mice, which mine their way very quickly under newly ploughed lands near the furface, is faid by Mr. Wagftaff, in the papers of the Bath Society, Vol. VI. to be effected in fome feafons to a very great extent. He adds, that the tuffocks of wheat, feen to arife in many fields, are owing to the granaries of thefe diminutive animals; which he has often found to contain nearly a hatful of corn, which grows into a tuft, if the owner becomes accidentally deftroyed.

Mr. Wagftaff alfo afferts, that they feed much on the young plants,

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as they arife from the feed, and multiply at that time very faft. He detects their habitations by fmall mounds of earth being thrown up on or near the apertures of their dwellings, or of the paffages, which lead to their nefts or granaries; and by following the courfe of thefe paffages he found and deftroyed the parents and the progeny.

Mr. Wagftaff recommends the taking up and dividing the tuffocks of wheat, thus fown in the autumn by the field-mice, and tranfplanting them in the fpring; and alfo to thin other parts of a young crop, as they appear too thickly fown, which he efteems an advantageous practice.

Acorns when fown, and garden beans, and peas, are liable to be dug up or devoured by thefe voracious little animals, which may be deftroyed by traps baited with cheefe; or beft of all by the encouragement of the breed of owls, fo active in the purfuit of nocturnal vermin, and thence fo ufeful to the gardener and farmer, who ftill permit their fervants and children to deftroy both their eggs and callow young.

2. This country was infefted with two kinds of rats, the houfe-rat and the water-rat; but it is believed, that within the laft half century the water-rat has deftroyed the houfe-rat. The water rats poffefs fome kinds of ingenuity fimilar to the beaver in the conftruction of their houfes near the brinks of rivers and pools; which have two apertures, one above ground amongft the grafs, and the other beneath the furface of the water; and unlefs they can hide their upper opening amid weeds or grafs, they forfake the fituation. Thus if a rim, three or four feet in breadth, round a fifh-pond be kept fo low as to rife only two, or three, or four inches above the level of the water; and if this be kept clean from high grafs, or weeds, the rats will defert the pond.

I have feen a young water-rat devour a large leaf of water-plantain, alifma plantago, and therefore fuppofe that they occafionally prey on the foliage, as well as on the feeds and fruits of vegetables, and on young animals, as ducklings and rabbits. As thefe animals, like the dog,

dog, are of a lafcivious nature, and as fome materials have a ftrong fcent, refembling perhaps that of their venereal orgafm, they are liable to be attracted by fuch fmells, as dogs are, on the fame account, I fuppofe, inclined to roll themfelves on putrid carrion; and male cats to eat marum, valerian, and cat-mint. On this account it is ufual for rat-catchers to avail themfelves of this propenfity, and to mix effential oil of rhodium, or mufk, with the poifonous powders of ftrychnos nux vomica, or of delphinium ftavifagria, or perhaps of arfenic.

The great injury to vegetation effected by thefe rats confifts in their making innumerable burrows beneath the foil, and feeding on the roots of a great variety of vegetables. Some new planted apple-trees I remember to have feen taken out of the ground with nearly the whole of their fmaller roots eaten, and the larger ones peeled by thefe reptiles. They will alfo deftroy young ducks, young rabbits, and young chickens; and devour with great avidity every kind of food, with which poultry and fwine are ufually fed; and are hence in many ways injurious in fituations near water.

The fubfequent receipts for poifoning this mifchievous vermin are printed in the papers of the Bath Agricultural Society, and faid to have been attended with great fuccefs. Firft, to a quart of oatmeal add fix drops of oil of rhodium, one grain of mufk, and two or three of the nuts of nux vomica finely powdered; make it into pellets, and put them into the rat-holes. This was at firft greedily eaten, and did great execution, but the wife animals after a time ceafed to eat it. The fecond confifted of three parts of oatmeal, and one of ftavifagria, ftave's-acre, mixed well into a pafte with honey. Pieces of this pafte were laid in their holes, and again did great execution. A third method of deftroying them there recommended is by laying a large box down on its front fide with the lid fupported open by a ftring over a pully; and by trailing toafted cheefe, and a red herring, from their holes to this box; and placing oatmeal and other food in this box, which they are for a few nights permitted to eat unmolefted; and finally to watch them by moonlight, the infide of the box being painted white; and, when many of them are feen, to let down the lid; by which contrivance fixty of them were taken at once.

3. Moles, as well as rats, have occafionally increafed fo greatly in numbers as to much injure the agricultor; they perforate the earth near its furface, and are faid never to drink, but to feed on the roots of vegetable, as well as on fubterraneous infects; and though they are believed never to drink, yet they have been feen occafionally to fwim over lakes of water to the iflands which they furround, of which an ocular proof is related in the tranfactions of the Linnean Society, Vol. III. 1797. Some have recommended to inject the fmoke of burning fulphur, or of tobacco, into their fubterraneous manfions; but as the earth frequently falls in behind them, as they pafs, or is accumulated behind them by their hindermoft feet, as they perforate the foil with their foremoft feet or hands, this method of attack can feldom fucceed, unlefs the neft of the animal be near the fumigated aperture. Others have advifed to pour water into their holes, which is equally inefficacious in general, though it may have effect in particular fituations. Some alfo have baited traps with worms, and others have advifed to put poifon into their holes; but they are not to be attracted together like rats from their not appearing above ground.

The following method was related to me by Francis Paget of Elfton near Newark, a very popular and fuccefsful mole-catcher, whom I once attended in his occupation to witnefs his operations. The moles have cities under ground, which confift of houfes, or nefts, where they breed and nurfe their young; communicating with thefe are wider and more frequented ftreets, made by the perpetual journeys of the male and female parents; as well as many other lefs frequented allies or bye roads, with many diverging branches, which they daily extend to collect food for themfelves or their progeny.

This

This animal is more active in the vernal months, during the time of the courtſhip of the males; and many more burrows are at this time made in the earth for their meeting with each other. And though theſe animals are commonly eſteemed to be blind, yet they appear to have ſome perception of light even in their ſubterraneous habitations; becauſe they begin their work as ſoon as it is light, and conſequently before the warmth of the ſun can be ſuppoſed to affect them. Hence his method of deſtroying them conſiſted firſt in attending their ſituation early before ſun-riſe; and at that time he frequently could ſee the earth move over them, or the graſs upon it; and by a ſmall light ſpade he frequently cut off their retreat, by ſtriking it into the ground behind them, and then dug them up. He added, that by laying the ear on a newly raiſed mole-hill, the ſound of the ſcratching mole might ſometimes be heard at a diſtance, and direct where to find it; as the ſolid earth conveys ſmall vibrations better, or to a greater diſtance, than the light air. And that a terrier dog, after having been accuſtomed to the buſineſs, was frequently of ſervice in detecting by his noſe the place of the mole beneath the ſoil, and by endeavouring to ſcratch the earth over it.

The mole he ſaid generally ſuckles four or five, and ſometimes ſix, young ones; which are placed conſiderably deeper in the ground than their common runs; and as theſe neſts are ſunk much deeper into the ground than their ſtreets or bye-roads, and the mole-hills conſequently larger, the earth on the ſummit of thoſe mole-hills is generally of a different colour, and is raiſed higher than that of the other ones. Theſe neſts are to be dug up, having firſt intercepted the canal between them and the mole-hills in their vicinity, to cut off the retreat of the inhabitants.

The next important circumſtance is to diſcover, which are the frequented ſtreets, and which the bye-roads, for the purpoſe of ſetting ſubterraneous traps. This is effected by making a mark on every new mole-hill by a light preſſure of your foot; and on the next morning by obferving whether a mole has again paffed that way, and obliterated the foot mark; and this is to be done two or three fucceffive mornings. Thefe foot-marks fhould not be deeply impreffed, left it fhould alarm the animal on his return, and he fhould form a new branch of road, rather than open the obftructed one.

The traps are then to be fet in the frequented ftreets, fo as nicely to fit the divided canal. They confift of a hollow femicylinder of wood with grooved rings at each end of it, in which are placed two noofes of horfehair, one at each end, faftened loofely by a peg in the center, and ftretched above ground by a bent ftick. When the mole has paffed half way through one of the noofes, and removes the central peg in his progreffion, the bent ftick rifes by its elafticity, and ftrangulates the animal. He added, that where the foil was too moift or tenacious, that the moles in paffing the old runs fometimes pufhed a little of it before them, and thus loofened the central peg before they were in the noofe; in which cafe he fixed the peg a little hafter in the trap.

By thefe means Francis Paget cleared many of the neighbouring parifhes of this kind of vermin in a few days, or a week or two, and laid them under an annual tax for the defence of their territories from thefe invaders. And added, that fome other mole-catchers had carried moles into thofe farms, whofe occupiers refufed to pay them an annual ftipend, a practice which he fcorned to ufe. I have detailed this method to prevent this impofition, and to enable every farmer to be his own mole-catcher, or to teach the art to his fervants.

PLATE IX.

PLATE IX.

Exhibits the aphis, puceron, or vine-fretter, and the infects which deftroy it.

Fig. 1. reprefents the aphis of the rofe-tree without wings very much magnified, copied from M. Bonnet, with its antennæ before, and its two horns behind, which are not half the length of the antennæ, are immoveable, and faid by Bonnet to be hollow canals from which the fweet juice called honey-dew is evacuated ; laftly, with the trunk under its head in the pofition in which it penetrates the leaves. In fome the horns behind are wanting, and little knobs fupply their place, which Reaumur thinks fupply the fame fweet juice. That fome poffeffing wings, and others not, does not diftinguifh the fexes is agreed by all obfervers.

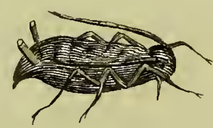
Fig. 2. reprefents a magnified aphis of a pear-tree, from which a young one is fufpended for fome time after it is otherwife born.

Fig. 3. reprefents the aphidivorous larva, with an aphis in its mouth, and the chryfalis of the fame infect, before it is transformed into the fly at fig. 4. All thefe were drawn from nature, and exactly refemble fimilar reprefentations in the work of Bonnet.

Fig. 5. reprefents an infect from Bonnet, which he terms an aphis lion, as it fo greedily devours the aphifes. This infect is transformed into the fly at fig. 6.

Fig. 7. reprefents a fpotted hemifpheric fcarabeus, called by fome a lady-bird, into which the infect at fig. 8. is transformed, which is alfo faid to be a great aphis-eater. Oeuvres de C. Bonnet, T. 1.

Fig. 1.



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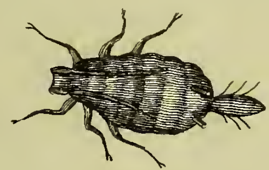

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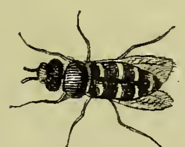

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PHYTOLOGIA.

PART THE THIRD.

AGRICULTURE AND HORTICULTURE.

SECT. XV.

THE PRODUCTION OF FRUITS.

Buds immediately from ſeeds never produce ſeeds. Neither in annuals nor trees. As in wheat, tulip, apple-tree. Buds from the broad caudex of a tulip, and the long caudex of trees, are of different maturity. Leaf-buds changed into flower-buds at Midſummer, or flower-buds into leaf-buds by art. I. To produce fruit-bearing trees. 1. *Seedling-trees. Their puberty. Ingraft walnut and mulberry trees. If unpruned young trees or eſpalliers bear fruit ſooner than other ſtandards? Buds on bended branches earlier and larger. An apple ſour on one ſide. How to produce fine ſeedling-trees or flowers. Leaves of ſeedling-trees.* 2. *Root-ſuckers from apples, vines, briers, figs, are like ingrafted ſcions.* 3. *Scions from branches planted in the earth. A quick-hedge thus raiſed. Chineſe method. Vines how raiſed by Mr. Michel.* 4. *An ingrafted ſcion ſometimes affects the ſtock. Acquires vigour from a vigorous ſtock. On trees of the ſame genus. On trees of different genus. Subject to hereditary diſeaſes, not to old age, like the parent tree. Summits die firſt. Talicotius's ingrafted noſes. Sour apple on one ſide. Apply rind to rind in grafting. Flower-bud not proper for inoculation. Sweeter apples have whiter bloſſoms. Colour of black cherry and purple grape known by their red leaves in autumn. Lines from Virgil's Georgics.* II. To increaſe the number of fruit-buds. *Leaf-buds are furniſhed with new caudexes down the trunk. Flower-buds not ſo. Retard the production of new caudexes. Viviparous and oviparous progeny. Production of new caudexes, or bark filaments, are compound in ingrafted trees, and ſuddenly generated.* 1. *Bend down the viviparous branches, and*

and they become oviparous, and receive more nutriment. Apple-trees trained in horizontal circles. Nectarines and peaches trained on the ground. 2. *Twist a wire or tie a cord round viviparous branches. Apple-trees become dwarfs by frequent ingrafting on them.* 3 *Wound or break a viviparous branch, or cut off a cylinder of the bark. The vessels of the alburnum sometimes act as capillary tubes. Decorticated oaks. Tapped birch and maple. Decorticate alternate branches about Midsummer. Decorticated roots produce root-scions. Grafted roots. Layers. Take bark off and replace it. Cut three or four circular incisions, or a spiral line. To make dwarfs.* 4. *Transplant a tree, or cut the roots, or confine them. Pluck up and transplant beans, brocoli, strawberries. Also crowd the roots of strawberries. Put a brick floor under fruit-trees. Confine lily of valley in pots. Orchis. Cucumbers and melons.* 5. *Cut away central viviparous branches. Why spurs are oviparous. Why terminal buds are viviparous. Effect of it. Management of melons. Management of vines. Pinch off viviparous secondary buds, and they become oviparous next year at the same eye. A longer heat to ripen the wood explained. If this could be practised on other fruit-trees.* 6. *Lines from Botanic Garden.* III. To perfect and enlarge the fruit. 1. *Shorten the oviparous branches. Cut away root-suckers.* 2. *Pinch off useless viviparous buds. Pick out secondary buds. And of melons.* 3. *Thin wall-fruits, and grapes. Mucor grows without light.* 4. *Tie waxed thread round twigs of fig-trees and pear-trees when in flower, to prevent new leaf-buds.* 5. *Give additional moisture, manure, and warmth. Moisture enlarges fruit by relaxing their cuticle, and preventing absorption from them. Of suckling gooseberries. Watering rice when in flower. Manure adds nutriment. Much warmth with much moisture both enlarges fruit and adds to its flavour. Hot-houses heated by steam. Pines cultivated in water.* 6. *Protect flowers and fruits from frost. A low situation is not proper for a garden. Walls covered with projecting coping stones are useful in spring, not in summer. Moveable coping sheds. Fire-flues in garden-walls. A secret in the management of them. Shade flowers from the sun.* 7. *Fruits ripen sooner if wounded, or gathered before they are ripe, or baked in the hot-house, or in an oven.* IV. 1. To preserve fruit. *Keep it from heat and cold, and from moisture. How heat and cold destroy the life of fruit. Congelation separates salts, vinous spirit, and vinegar, from water. Condenses clay. Repels mucilage. Thaw frozen fruit slowly. Preserve fruits in ice-houses, or by steam.* 2. *Gather fruit during*

 its

its acid ſtate. Evaporate part of its water. Keep it cool. 3. *Impregnate fruit with ſugar. Brandy poiſons mucor or mould.* 4. *Fruits preſerved in brine, in vinegar, in ſpirit of wine, ratifie.* V. Verſes *on pruning trees and melons.*

THE objects of the culture of the farm or garden may be divided into the production of fruits, ſeeds, roots, barks, woods, leaves, and flowers.

We have repeatedly endeavoured to ſhew, that the buds immediately ariſing from ſeeds are not themſelves capable of producing ſeeds neither in herbaceous nor in arboreſcent vegetables; but that the firſt bud from every ſeed is ſucceeded by a ſecond bud more perfect than itſelf; and that by a third, fourth, or many more; each generation being more perfect than the preceding one, till they acquire a puberty, if it may be ſo called, or a power of producing ſexual organs, and a conſequent ſeminal progeny.

In thoſe plants, which are called annuals, becauſe their ſeeds are ſown, and produce other ſeeds, in the ſame year, and then periſh, ſome ſucceſſive buds grow on each other, before a flower can be produced; as is ſeen in the ſtems of wheat, and ſowthiſtle, triticum, ſouchus; which conſiſt of joints, which appear to be ſucceſſive buds growing on each other.

From the tulip ſeed a ſingle bud ariſes the firſt year with a circular flat caudex exiſting beneath it, on which one principal new bulb is formed annually more perfect than its parent, as is ſeen by the larger leaf; and alſo ſome leſs bulbs are produced around the more perfect one in the boſom of each rudiment of a leaf, which compoſes or encloſes the principal bulb, as deſcribed in Sect. VII. 1. 3. and Sect. IX. 3. 1. and 3. 6. Theſe leſs perfect bulbs round the principal one, after the principal one has acquired its puberty, or power of producing ſexual organs, are of greater or leſs degree of maturity, as appears by their ſize; and thence I ſuppoſe muſt require more or fewer years, before they flower.

Similar

Similar to this circumſtance of the tulip-root, the buds of trees, which firſt ariſe from the ſeed, produce annually other buds more perfect than themſelves, till they acquire the power of ſeminal generation; and afterwards not only a flower-bud is formed, which is in ſome trees the central bud on the extremity of the twig, as in pear-trees, and on the ſpurs of apple-trees; but alſo many leaf-buds of greater or leſs maturity are formed around the principal, or flower-bud; which require more or fewer years, before they obtain the maturity neceſſary to produce a flower.

It was ſhewn in Sect. VII. 1. 7. that every part of the long caudex, extending from a bud on the ſummit of a tree to the root, can produce a bud, like every part of the broad caudex of a tulip-root; but thoſe produced in the boſom of the leaf I believe generally to be the moſt mature; and thoſe which ariſe from a lower part of the caudex to be leſs mature, and will in conſequence require more ſucceſſive buds to proceed from them, before they can form a flower. Thus when the whole branches of a fruit-tree are lopped from the trunk, the new buds are produced from the lower parts of the caudexes of the branch-buds, which have been lopped off, and are therefore an immature progeny, and require ſome years before they can flower.

It hence appears, that a number of buds or bulbs in all vegetables muſt ſucceed each other from the ſeed, before a flower and conſequent fruit can be generated; but that theſe ſucceſſive generations are more numerous or fewer in ſome plants than in others; that they in ſome plants may only ſucceed each other annually; in others perhaps many of them in the ſame ſummer, as in the herbaceous plants, as wheat; and in thoſe trees, whoſe annual joints have their pith divided from each other, as in vines. And laſtly, that the number of theſe ſucceſſive generations, or the times of their production, whether only annually, or many of them in one ſummer, may be diminiſhed

niſhed or accelerated by art; and that in attending to all theſe circumſtances conſiſts the ſuccefsful management of fruit-trees.

The new buds on deciduous trees in this climate are produced about Midſummer, as obſerved in Sect. IX. 2. 9; and it is believed by the Linnean ſchool, that many of them at this time may be ſo affected by art, as to become either leaf-buds or flower-buds. At this ſeaſon therefore the production of buds on wall-trees, or eſpaliers, or on ſtandards, ſhould employ the attention of the horticultor; as thoſe ſeedling-trees produce leaf-buds only, which are too young to produce flower-buds; and as the particular ſhoots or buds of other trees are not ſo mature as to produce flower-buds; and laſtly, as ſome trees flouriſh too vigorouſly, as it is termed, to produce flower-buds. The things to be attended to are the age of the tree, from which the graft was taken, which now forms a branch; the maturity of the particular buds, which you wiſh to encourage; and the vigour of the whole tree, or its tendency to produce leaf-buds in preference to flower-buds.

I. TO PRODUCE FRUIT-BEARING TREES.

1. There are four methods of procuring fruit-trees for the purpoſes of horticulture, by ſeeds, by root-ſuckers, by planted ſcions, or by ingrafted ſcions.

1. *Of Seedling Trees.*

It was obſerved above in Section IX. 3. 1. and 3. 6. that in tulips and hyacinths, and even in potatoes and onions, the bulbs ſucceed each other for two or three years or longer, before they produce flowers; and that the ſame happens to the buds of ſeedling-trees, which are many years a ſucceſſion of leaf-buds only, before the propagation of a ſingle flower-bud; for the power, which produces the lateral germination of buds, ſeems to require a leſs mature organization than that, which is employed in the ſexual generation of ſeeds; whence a kind of puberty of the plant ſeems to be acquired for the production of the ſeminal or amatorial progeny, analogous to the transformation of caterpillars into butterflies; which appears to be effected ſolely for the purpoſe of propagation.

M. Speechly, in his treatiſe on the Culture of the Vine, p. 49, ſeems to ſay, that ſeedling vines muſt be three or four years old, before they produce fruit; whereas a planted ſcion, or an ingrafted one, from an aged tree, will produce fruit the firſt or ſecond year; and according to the obſervations of Mr. Knight, ſeedling apple-trees will not bear fruit till they are twelve or fourteen years old; and other fruit-trees in ſimilar manner require ſome years after their birth from the ſeed, before they arrive at ſufficient maturity to bear flowers. See Sect. VII. 1. 3. Hence he adviſes the horticultor to procure ſcions for grafting from ſuch trees as already bear fruit; but pays no regard to the ſtock, into which they are to be inſerted; and adds, that he believes, if ſcions from a bearing walnut or mulberry tree were ingrafted on a ſeedling one, that it would produce fruit in two or three years; which otherwiſe would not occur in leſs than twenty. Treatiſe on Apple and Pear. Longman, London. And hence we ſee the advantage of ingrafting on ſeedling orange or lemon-trees in our green-houſes the ſcions taken from thoſe, which bear fruit; as otherwiſe they would continue ſo many years before the buds would acquire ſufficient maturity to generate flowers.

Some have believed that young trees will bear fruit ſooner, if they are not pruned, but permitted to grow quite wild in large buſhes. It is poſſible, that this may occur either from the unſkilful horticultor pruning off all the terminal twigs, whoſe buds were forwarder in reſpect to age, than the lateral ones much beneath them. Or becauſe the great number of new leaf-buds, proceeding from an exuberant branching head, may ſo crowd the bark of the trunk with their

their caudexes, that ſome of them may ſooner find a difficulty in forming their embryon caudexes, and may in conſequence become flower-buds. But I much doubt, that this can frequently occur from either cauſe, as I think, I have ſeen eſpaliers bear ſome years ſooner than ſtandards, which were ingrafted at the ſame time, and from the ſame trees. And I have been informed of other ſeedling apple-trees, which have born fruit in not much more than half the time above mentioned by Mr. Knight.

It is much to be wiſhed, that proper experiments were made on ſeedling trees by planting them as eſpaliers, or againſt walls, and bending down their branches below the horizon, ſince the difficulty of their generating leaf-buds might be thus increaſed; as they could not ſo eaſily form their embryon caudexes on the compreſſed bark of the bended branch; and the ſap-juice for the nouriſhment of fruit-buds would be thus rather increaſed than diminiſhed, according to an experiment of Dr. Walker, who found the buds at the extremities of bended branches to ſwell ſooner in the ſeaſon, and to become larger, than thoſe of an equal height on the more upright branches. Edinburgh Tranſactions, Vol. I.

Mr. Bradley has mentioned an apple, which was ſweet and boiled ſoft on one ſide, and ſour and boiled hard on the other; and aſcribed it probably to the real cauſe with much ingenuity in the year 1721, long before the publication of the ſyſtem of Linneus. He aſcribes it to the male farina of ſome neighbouring harſh apple-tree affecting at the time of the impregnation the ſtigma of the flower of a ſweet one; and thus a production of different ſeeds might be generated in the ſame pericarp, and a conſequent different kind of nutriment prepared for each; and thus the different parts of the apple become ſour or ſweet, which is analogous to a bitch producing different kinds of puppies at the ſame birth, reſembling the different dogs with which ſhe had cohabited. The ſame circumſtance is ſaid to have occurred in oranges and in grapes of different kinds.

By this method of applying the farina of one good variety of fruit, as of apple or pear, to the ftigma of another good variety, it is very probable, that fome very excellent new varieties of fruit might be produced from the feeds, which might fupply for a century the orchards of the curious, inftead of our golden pippins, and nonpareils; which are faid to be fuperannuated, and fo liable to canker as not to be worth cultivation. It is probable alfo, that new varieties of tulips and hyacinths, and of melons and cucumbers, as well as of all other vegetables, might be thus produced.

The following obfervations are from Mr. Knight's treatife on Apple and Pear, p. 47. "Every feed, though taken from the fame apple, furnifhes a new and diftinct variety; and fome of thefe will grow with more luxuriance than others; and the fruits produced by the different plants will poffefs different degrees of merit; but an eftimate may be made of their good and bad qualities at the conclufion of the firft fummer by the refemblance the leaves bear to the highly cultivated, or to the wild kinds; as has been remarked by the writers on this fubject of the laft century. The plants, whofe buds in the annual wood are full and prominent, are ufually more productive than thofe whofe buds are fmall and fhrunk into the bark; but their future produce will depend much on the power the bloffoms poffefs of bearing cold; and this power varies in the different varieties, and can only be known from experience. Thofe, which produce their leaves and bloffoms rather early in the fpring, are generally to be preferred; for though they are more expofed to injury from froft, they lefs frequently fuffer from the attacks of infects, the more common caufe of failure.

"The leaves of young feedling plants annually change, become more thick and flefhy, and affume more the character of the cultivated kinds. Thefe external changes indicate fome internal ones in the conftitution of the plant, which may poffibly be fimilar in their nature to thofe, which take place in animals between their infancy

fancy and the time, when they become capable of propagating their ſpecies.

2. *Of Root-ſcions.*

Root-ſuckers from bearing bur-apples, or from bearing codlings, are believed to become fruitful as ſoon as grafts from thoſe trees; becauſe they are a viviparous offspring, as well as the ſcions or twigs from the branches; and are therefore not ſimilar to the oviparous progeny, or the young trees produced from ſeeds. This muſt nevertheleſs in great meaſure depend upon the age of the ſucker; as thoſe root-buds, which riſe into ſuckers, are not formed or generated in the boſom of a leaf, but from a part of one of the long caudexes of a branch-bud; and will therefore, I ſuppoſe, require a ſucceſſion of buds for ſome years, before they will acquire ſufficient maturity to produce a flower; as the central buds from the boſom of a leaf I ſuppoſe to be much forwarder than the lateral buds from the ſame caudex; as is ſeen in the central or flower-bulb of a tulip, and its immature lateral bulbs from the ſame caudex.

Root-ſuckers from thoſe trees, which have been ingrafted on the roots of other trees, as the robinia on the acacia, may ariſe above the grafted part, which is beneath the ſoil; but thoſe root-ſuckers, which ariſe from trees, which were grafted above ground, are ſimilar to the ſtock, not to the fruit-bearing head; which might have been a wild pear or wild apple; and will in that caſe produce crab-pears, or crab-apples, with thorny ſtems.

When a branch of a vine, or briar, or of many other trees, is bent down, and a part of it inſerted into the ground with its ſummit in the air, it will emit roots at the joints, and become a new tree. So the rough knobs on the bark of a bur-apple-tree, I am informed, will ſhoot out roots, if ſurrounded with moiſt earth; and the branch may be then cut off, and ſucceſsfully planted. And from almoſt every joint of a fig-tree roots will protrude, if ſurrounded even with a woollen

woollen ſhred, which happens to be frequently moiſtened by the dews or rain; and the branch may be ſucceſsfully bent down and planted in a garden-pot. All theſe, like ſuckers from the roots of ſeedling-trees, or like grafted ſcions, will become fertile, as ſoon as the tree, from which they are the offspring; whether it be a ſeedling-tree or not.

This circumſtance does not occur exactly ſimilar in the inſertion of buds from one tree into the bark of another; as thoſe buds, which do not ariſe from the boſom of a leaf, but from lower parts of the caudexes of a branch-bud, as from the bark of a branch, whoſe ſummit has been cut off, are leſs mature, I believe, than the ſummit-buds, or thoſe which ariſe from the boſom of a leaf; and will therefore require ſome years before they can produce flowers; as is ſeen in thoſe apple or pear trees, whoſe ſummits have been entirely lopped off. This is a new obſervation, I believe, and worth the attention of thoſe, who inoculate the buds of one fruit-tree into another.

Root-ſuckers may probably be liable to degenerate in reſpect to their vigorous growth by hereditary diſeaſes, owing to the too great age of the original plant of that variety, like the ingrafted ſcions from the branches. Whence it may be neceſſary to procure root-ſuckers of raſpberry-plants, and of gooſeberries, and even of artichokes, and ſtrawberries, from ſuch as have been raiſed from ſeed not too long ago, when any of theſe begin to degenerate.

3. *Of Planted Scions.*

The ſcions taken from the branches of many trees, if planted in the earth, will emit roots, and flouriſh in the ſame manner, as when they are grafted on other trees. This ſucceeds with great certainty, if an inverted glaſs be put over them for a few days to prevent their perſpiring more at firſt, than their abſorbent veſſels can ſupply. See Sect. I. 1. I have been informed, that a quickſet, or hawthorn

 hedge,

hedge, cratægus, was thus planted and became a good fence confiderably fooner than from fowing the feed.

The Chinefe are faid by fir G. Staunton to be unacquainted with the art of ingrafting, and to produce dwarf fruit-trees, which are brought to table loaded with fruit at their feftivals, by furrounding a branch of a bearing fruit-tree at its bifurcation with a bag of earth, which is kept moift for fome months; till the branch puts out roots, probably from the lips of a wound in the bark, and is at length feparated, and tranfplanted into a pot. Embaffy to China, Vol. II. p. 54, 8vo. edition; and it is then rendered a dwarf by repeatedly cutting out the central buds, as in the management of melons, as mentioned in No. 2. 5. and 3. 2. of this Section.

Vines poffefs fo vigorous a power of vegetation, that the prefent moft approved method of propagating them in grape-houfes confifts in planting their fcions. The late Rev. John Michel of Thornhill, in Yorkfhire, the philofopher, who difcovered to the world the art of making artificial magnets, which had been concealed by Mr. Knight; whofe friendfhip I long poffeffed, and whofe lofs I have long lamented; amufed himfelf and family at vacant hours in his hot-houfe. The obfervations of a man of fuch accurate and univerfal knowledge are always worth recording; and though his ideas on this fubject have already appeared in Mr. Speechly's Culture of the Vine, I fhall here tranfcribe a part of one of his letters to me dated in May 1785.

" The way in which we raife our vines we account our own; for I don't know, that it was practifed by any body before we fet the example. It is now pretty generally adopted however by the gardeners and nurferymen in this part of the world. Inftead of leaving three or four eyes on the cuttings, as ufed formerly to be done, which made them awkward ftraggling things, we never plant more than a fingle eye to each, cutting them with as long a part below the eye as they can admit, without encroaching too much upon the next eye below; that is to fay, we leave perhaps about half an inch, or or a little more, as it may happen, above it. Thefe cuttings we plant by half a dozen or a dozen together, at the diftance of three, four, or five inches, in the bark-bed, where it is pretty warm, but not fo hot as to endanger the burning of the roots, when they fhall come out; and where it is alfo pretty moift, or elfe we water them. We plant them floping fo as to make an angle of about thirty degrees perhaps, a little more or lefs, with the horizon, the eye being higheft; but taking care that it alfo fhall be covered about an inch with the bark, which is a very neceffary precaution; for though it ought juft to *fmell* the frefh air, it muft be kept moift, to prevent the bud and fhoot, when it comes, from drying; otherwife it will very frequently die away prefently after it has fhot a little, or at beft it will grow unkindly, not having yet made roots fufficient to fupply it with the fap neceffary for its fupport; which will not be the cafe, if the bud is fufficiently covered at firft, and till it has acquired more roots.

We generally plant our vines in this way, about the beginning or middle of January; and if the bark is pretty warm, and as moift as it fhould be, the cuttings will begin to pufh both at top and bottom in about a fortnight or three weeks at the moft. When the vines have fhot a little, perhaps three or four inches, but before the roots are got too long, (in which cafe it would be impoffible to avoid breaking them by removing, on account of their extreme tendernefs and brittlenefs) we difplace a good deal of the bark very near them, till we can throw them down all together, which fhakes the bark very gently from their roots; fo that one may difengage them fufficiently eafy, and without much hurting them. We then plant three or four of the moft promifing and thriving ones out of the whole number fingly in fmall pots in earth, which has previoufly ftood in the hot-houfe a day or two to get warm, letting the roots drop down on a little earth at the bottom, at firft, as they conveniently can, and then covering them with more earth carefully, till the pot is properly filled, and the ftem about three or four inches long, as I faid before,

before, ſtanding in the middle; and then plentifully watering the earth to ſettle it to the roots. We now plunge them again in the bark, where in five or ſix weeks, more or leſs, they will have filled their pots pretty well with roots; when they will begin to ſhew by their little progreſs, and the ſmallneſs of the ſhoots, that they want more room. We then take them carefully out of theſe ſmall pots, diſturbing the ball of earth as little as poſſible, and put it all together into larger pots, putting a little freſh earth at bottom and round about, and watering well as before; and we then again plunge them into the bark.

"By about the latter end of May, or beginning of June, the beſt of them will be four or five, or perhaps ſix feet high, and ought now to be removed, diſturbing the roots as little as poſſible, into the natural ground, where they are to remain. If this is done carefully, and the earth well watered about them to ſettle it to their roots, they will frequently begin growing again almoſt immediately, but at leaſt in three or four days; and will then often ſhoot in the hot-houſe two inches in a day, and by the end of the year will have ſhot from eighteen or nineteen, to three, four, or five and twenty feet. Though we approve of this as rather the beſt, yet if theſe cuttings are planted in the ſame way either ſingly in ſmall pots, or two or three together in each, with earth, inſtead of planting them in the bark, deſtroying all but the beſt one, when they have ſhot a little, and plunging them either in the bark, or in default of a bark-bed, in a common hot-bed, they will do equally, or nearly equally well; only taking care, that the hot-bed is not too hot, ſo as to injure the roots, of which there is ſometimes danger."

4. *Of Ingrafted Scions.*

The art of ingrafting trees is of great antiquity, and is attended with numerous well known advantages, but is not yet arrived to its utmoſt perfection; for it is not yet certainly known, whether the ingrafted ſcion gives or takes any property to or from the tree, which receives it, except that it acquires nouriſhment from it.

There is one inſtance recorded by Bradley, where the ſcion of a variegated jaſſamine gave variegation to the leaves beneath it of the unvariegated jaſſamine, on which it was ingrafted, though the graft itſelf periſhed. See Sect. V. 1. This ſeems to ſhew, that a communication of juices exiſts between the graft and the ſtock; and that thus ſome change in the colour of the leaves of the ſtock might be occaſioned by the inoſculation of the veſſels of the new bud with thoſe of other buds in its vicinity. Thus if a ſcion of a purple grape was ingrafted on a white one, the leaves of the latter might probably become ſomewhat red in the autumn, like thoſe of the purple-vine; but there are no inſtances recorded, where this communication of juices from the graft to the ſtock, or from the ſtock to the graft, has varied the flavour or the form of the flowers, or fruit of either of them.

For though the ſame vegetable blood paſſes along both the upper and lower part of the caudex of the new ſcion, which extends from its ſummit on the branch to its baſe in the earth; yet the molecules ſecreted from this blood are ſelected or formed by the different glands of the part of the caudex, which was brought with the ingrafted ſcion, and of the part of it which remained on the ſtock, in the ſame manner as different kinds of ſecretions are produced from the ſame blood in animal bodies.

Some have nevertheleſs believed, that ſcions, ingrafted on more vigorous trees of the ſame genus, have acquired greater vigour in the growth both of their leaf-buds and fruit-buds. Mr. Speechly aſſerts, that he has improved many kinds of vines by ingrafting thoſe, which bear ſmall grapes, and which have generally weak wood, on ſtronger ones, which he has often experienced; and recommends the Syrian vine to graft upon, and prefers thoſe, which were raiſed from ſeed for this purpofe; and the contrary feems to appear, where more vigorous fcions have been ingrafted on lefs vigorous ftocks; as apple-fcions on crab-ftocks; where in a few years the part above the grafted joint becomes much larger in diameter than that below it.

Grafted fcions fucceed well in general on trees of the fame genus, as in the common ingraftment of fruit-trees; fo the laurel, prunus lauro-cerafus, will grow on the common cherry, prunus cerafus, and produce a tall evergreen tree. But there are faid to be inftances alfo of fuccefs in the ingraftment of trees not only of different genera, but even of different orders, and claffes; as I have been informed, that apple-fcions, pyrus malus, have grown, when ingrafted on hazels, corylus. And one of the fathers of the Carthufian order is faid to have fucceeded in grafting a vine, vitis, on a fig-tree, ficus; and a jaffamine on an orange. Travels in France and Italy, by E. Wright. It is hence probable, that many new difcoveries might be made by more frequent experiments on this fubject.

It neverthelefs appears, that in grafted trees, though the ftock annually becomes covered with a new bark, as well as the graft, yet it does not change its nature; fince any new buds, which come out from the ftock afterwards, are fimilar to the ftock, not to the graft; and in many trees the graft grows fo much fafter as to become nearly of double the diameter of the ftock, as is frequently feen in old cherry-trees, and is fpoken of in Sect. VII. 1. 7.

Thus the buds of fruit-trees, like the bulbs of tulips, when raifed from feed, annually improve in their colour, length, thicknefs, and often in the fhape of their leaves, for a certain number of years; and then acquire a male, or a female, organ of reproduction, as in the claffes of monœcia, and diœcia; or both, as in hermaphrodite flowers. After this period the central buds and bulbs annually produced are in every refpect fimilar to their parents, as mentioned in Sect. VII. 1. 3. except in the nearer progrefs to old age of the tree, or of the bulb-progeny; and the confequent tendency to hereditary difeafes. But the lateral buds from the lower parts of the caudex of the central ones, which are not generated in the bofoms of leaves, are of a more immature kind, and in that refpect do not refemble the central bud, or bulb; but require fome years before they flower.

Mr. Knight has obferved, that the grafts from thofe fruit-trees, which have been in public eftimation for a century or two, are now fo liable to canker, that they bear very little fruit, and are not worth cultivation; which he afcribes to the age of the tree; as a graft he fays is fimply an elongation of the parent tree. And as it demands fome years to acquire the puberty neceffary for fexual generation, fo it may become weak and inirritable by age, and perifh about the fame time with the original tree; which is fomewhat countenanced by another remark of Mr. Knight, that the fummits, or long extremities of old trees, frequently die many years before fome fmaller branches from the trunk, which continue to flourifh, as is frequently feen in old oaks as well as in fruit-trees; and which he might fuppofe to be occafioned by the greater age of the terminal buds than of the lateral ones, as well as from the greater length of their abforbent veffels, and the confequent greater refiftance to the afcent of the fap-juice, which may alfo be fooner impeded, or totally ftopped by the inirritability of old age.

Neverthelefs as the buds of trees are fucceffive progenies, and cannot therefore be liable to old age, as they die annually; the degeneracy of the buds of very old trees, or of thofe which have long fucceeded each other by their lateral, and not by fexual generation, muft arife from their being liable to hereditary difeafes only, and not to hereditary improvements, as obferved above in Sect. XIV. 1. 6.

That the degeneracy of fome plants is owing to hereditary difeafes, and not to old age, appears from their continuing for long uncounted periods of time after the production of thefe difeafes, as berberries without feeds, and vines without feeds, and ftrawberries without fruit, though probably with feeds, as the barren hautbois ftrawberries, ſtrawberries, which bear no fruit, ſo called, have perfect ſtamina and piſtilla, as I this day obſerved with a good lens; to which may be added thoſe female figs, which have no aperture to admit impregnation, and the monſtrous double flowers, which have loſt the power of ſeminal propagation, and ſome mule-plants, which never poſſeſſed it.

We have nothing in the animal ſyſtem, except in the polypus, and a few obſcure inſects, ſimilar to lateral generation; and cannot therefore decidedly argue on this ſubject. Nor have we any thing ſimilar to ingraftment in animals, except that of inflamed parts growing together, the tranſplantation of teeth, and conſtruction of artificial noſes from the ſkin of the patient's arm, ſeriouſly delivered by Talicotius, with many engraved plates in a work on that ſubject. But this ingraftment of noſes was unfortunately burleſqued by the author of Hudibras; and perhaps this ingenious idea of Mr. Knight, that the ingrafted ſcion becomes diſeaſed by age, and periſhes about the ſame time with the parent tree, may be liable to a ſimilar ridicule by ſome future writer on gardening.

So learned Talicotius from
The brawny part of Porter's bum
Cut ſupplemental noſes, which
Would laſt as long as parent breech;
But when the date of Knock was out,
Off drop'd the ſympathetic ſnout.

Canto I. l. 281.

There is an apple ſaid to exiſt at New York in America, which is aſſerted to be ſour on one ſide of it, and ſweet on the other ſide; and to have been produced by ſlitting a ſcion of a ſour apple, and another ſimilar one of a ſweet apple, taking care to cut the buds of each ſcion with a very ſharp knife exactly in half, and by applying them and binding them nicely together, and then ingrafting this double

9 ſcion

ſcion on a tree. I mention this, as it is related by Mr. Jay in the communications to the Board of Agriculture, Vol. I. part 3 and 4, p. 362; and is referred to in the Memoirs of the American Academy, Vol. I. p. 386. But there muſt undoubtedly have been ſome miſtake in reſpect to the production of ſuch an apple by any method of grafting, and which is ſo well explained as above by Mr. Bradley.

It only remains here to add in reſpect to grafting, that it is neceſſary to apply the bark, which contains or conſiſts of the caudex of the young ſcion, exactly to the bark of the branch, into which it is inſerted, or applied; and then all ſpecies of ingrafting ſucceeds, whether it is performed on a branch or on a root; and whether by exciſion, or inoculation, or inarching. But I ſuſpect, that where a ſingle bud is inoculated, it has often failed from the unſkilful operator having ſelected a flower-bud inſtead of a leaf-bud; which probably unites its caudex to thoſe of the ſtock with leſs vigour, and certainly dies after it has ripened its ſeed; or by his imprudently holding the bud in his mouth, as he aſcends the ladder, or while he makes the inciſion, and thus deſtroying it by heat, as I once obſerved. A leaf-bud may in general be diſtinguiſhed from a flower-bud by its being ſharper pointed and leſs ſpherical.

Where the ſummits of very young ſcions of only a few weeks old are to be uſed to ingraft with and upon, it may be neceſſary alſo to apply the pith exactly to the pith; as this ſummit bud is yet a primary being, and not like a lateral one, whoſe whole caudex exiſts in the bark, which adheres to it, when it is taken off for inoculation.

The choice of buds for the purpoſe of inoculation is probably of more conſequence than has hitherto been imagined. As we have endeavoured to ſhew, that buds from parts of the bark diſtant from the central bud, and which are not generated in the boſom of a leaf, are in different ſtates of maturity; they muſt require more years before they can produce a ſexual progeny of flowers, and a conſequent

ſeminal

feminal offspring, with the refervoir of nutriment, or fruit, which attends it. A fubject which is new, and merits to be further inquired into.

It is curious to obferve, that when harfher fruits become fweeter, that the bloffom becomes whiter, as is univerfally feen in thofe of our native crabs, and of our cultivated apples; and that the buds become larger, and the green leaves alfo become of larger area, and of paler complexion.

Thus Mr. Knight obferves, "that the width and thicknefs of the leaves generally indicate the fize of the future apple; and the colour of the black cherry and purple grape may be known by their autumnal tints; and that even in plants, which have fprung from feed in the preceding fpring; as the tinging matter in the leaves of thefe plants is probably of the fame kind as that, to which the fruits will in future owe their colour." The leaves of the purple grape become quite red in autumn, as well as thofe of the geranium robertianum, and many other kinds of foliage, which I fuppofe may be owing to their abundancy of acid, which uniting with the blue part of what conftitutes along with the yellow part the green colour of vegetable leaves, converts it to red; as it changes the colour of blue flowers into red ones.

5. A tranflation of the beautiful lines in Virgil's Georgics on ingrafting may amufe the reader.

Where cruder juices fwell the leafy vein,
Stint the young germ, the tender bloffom ftain;
On each lop'd fhoot a fofter fcion bind,
Pith prefs'd to pith, and rind applied to rind.
So fhall the trunk with loftier creft afcend,
And wide in air robufter arms extend,
Nurfe the new buds, admire the leaves unknown,
And blufhing bend with fruitage not its own.

II. TO INCREASE THE NUMBER OF FRUIT-BUDS.

The terms ſtrength and weakneſs, in their uſual acceptation, when applied to the vegetation of trees, are metaphorical expreſſions, or denote the effect or conſequence, rather than the cauſe, of their bearing leaf-buds or flower-buds, as ſpoken of in Sect. IX. 2. 7. For the production of leaf-buds, or flower-buds, though it may be ſaid to accompany the greater or leſs vigour of a tree, depends on the facility or difficulty, with which the long caudexes of the new buds, which conſtitute the filaments of the bark, can be generated.

Thus the new vegetable production formed in the axilla of a leaf about Midſummer, which is called a leaf-bud, conſiſts of many embryon buds, perhaps twenty or thirty, which are to form the next year's ſhoot; and each of theſe muſt be furniſhed at the ſame time with a long caudex in miniature, extending from the leaf or ſummit to its radicle or baſe; which conſiſts of umbilical veſſels for its vernal nutriment, and of a continuation of other abſorbent veſſels, and of arteries and veins, as deſcribed in Sect. VII. 1. 7. which paſſes along the branches and trunk from the apex or leaf of the bud in the air to its baſe or radicle in the ground; and which thus forms the new bark, and contributes to thicken and ſtrengthen the trunk and branches of the tree; becauſe each new leaf-bud with its ſummit, caudex, and radicle, continues afterwards to adhere to the parent tree.

But the production in the axilla of a leaf, which is called a flower-bud, or fruit-bud, conſiſts only of an individual vegetable with the rudiments of a number of flowers, with one caudex for its growth and nutriment; for as the ſeed falls from the tree, when ripe, no new apparatus of caudexes in miniature for each individual ſeed, as for each individual embryon-bud, is required to paſs down the trunk into the ground to form a new bark; and thus to thicken and to ſtrengthen the trunk and branches.

Add

Add to this, that not only the feeds require no new caudexes to pafs down the trunk, but that probably the ftamina and coral of each flower ftrike their roots only into the blood-veffels, which communicate with the bractes, like moffes or fungufes, which grow on trees, or like cufcuta, dodder, vifcum, mifletoe, and tillandfia, and epidendrum; and therefore require no caudexes and radicles to pafs down into the ground.

Whence it appears, that by rendering it more difficult for new buds to acquire new caudexes along the branches or trunk from the fummit into the ground, the tree will be neceffitated to produce flower-buds in preference to leaf-buds; a theory, which was firft delivered in the Botanic Garden, Vol. I. canto 4. l. 470, note, and explains the whole art of the management of fruit-trees.

Vegetables therefore in refpect to their mode of propagation are either viviparous or oviparous. The live progeny of vegetables confifts of the buds, which rife on their branches in the bofom of each leaf, or on its long caudex extending down the bark of trees; or which arife on the bulbs, knobs, wires, or fcions, from the broad caudex on the roots of herbaceous plants. The egg-progeny of vegetables confifts in their feeds, with the previous apparatus of the flower, and concomitant nutriment in the fruit and cotyledons. And as plants, or parts of plants, are faid to be in greater vigour, when the viviparous progeny is prevalent; as the caudexes of this adherent offspring form a new bark, and thence thicken and ftrengthen the trunk and branches; and to be in lefs vigour when the oviparous progeny is prevalent; as the feeds fall from the tree, and confequently require no caudexes to form a new bark, and thence to thicken and ftrengthen the tree. We fhall generally ufe the word viviparous inftead of vigorous, when applied to vegetables, which generate leaf-buds principally; and oviparous inftead of weak, when applied to vegetables, which generate flower-buds principally; for the words vigorous or weak may properly exprefs the greater or lefs health of vegetables in both thefe fituations.

The reader will pleafe to obferve, that in the Botanic Garden we have called the bark of trees an intertexture of the roots of each individual bud; but that this is not accurate language, as the filaments, which conftitute the bark, are each of them the caudex of a bud, or central part of it; which has a leaf at its upper extremity, and a radicle at its lower one. And that each new caudex, or bark filament, is generated along the whole trunk of the tree by the caudex or bark filament beneath it; as appears in thofe fruit-trees where one, or two, or three fcions have been ingrafted on each other, as mentioned in Sect.VII. 1. 7. for in thefe compound trees, when a bud arifes from any part of the trunk, it is feen to refemble that part of the ftock, and not to refemble the new grafted fcion above it. We finally fuppofe, that this whole long caudex of a new bud is generally generated all at the fame time by the fympathetic action of the parts of the parent caudex along with the bud in the bofom of the leaf of that parent caudex; and that it is not gradually produced, as we firft fuppofed, by the elongation of the roots of each budlet in the bofom of the leaves.

The following methods will contribute to prevent the young buds from fo readily acquiring new caudexes on the trunk of the tree; and will therefore retard the generation of leaf-buds, and confequently affift the generation of fruit-buds; and fhould be executed about Midfummer, or foon after, as at that time the new buds are formed.

1. *The firft method confifts in bending the viviparous branches to the horizon, which converts them into oviparous ones*, for by the curvature of fuch branches the bark will be compreffed on the under fide, and extended on the upper fide of the curve, and its veffels on both fides will be contracted in their diameters, and thus the difficulty of producing new caudexes for the generation of embryon leaf-buds will

be increafed, in whatever ftate of miniature they may be conceived to exift.

A curious fact feems to be eftablifhed by the experiments of Dr. Walker in the firft volume of the Edinburgh Tranfactions, which fhews, that the bending of a branch even below its infertion into the trunk does not impede the afcent or derivation of the vernal fap-juice into it; but on the contrary, that it rather appears to affift it, refembling in fome meafure a capillary fyphon, as mentioned in Sect. III. 2. 4. which may be owing to the vernal fap-juice afcending principally, or entirely, in the fap-wood, as appears by the new leaves expanding to a certain degree on decorticated oak-trees, as fhewn in Sect. IX. 2. 8. And as the veffels of this alburnum are more rigid, they may be lefs liable to contraction or coarctation by bending down the branch than the bark-veffels, as well as from their being placed within the latter, and therefore lefs liable to compreffion beneath the curvature, and to elongation above it.

Whence it appears, that the bending down a branch of a fruit-tree below the horizon does not diminifh the nutriment of the fruit-buds, but rather increafes it; as Dr. Walker obferved thefe buds to grow fooner and larger at the extremities of the bended branches than on other parts of equal height.

It was afferted by Mr. Lawrence, that the more the branches of any tree are carried horizontally, the more apt that tree is to bear fruit; and that the more upright or perpendicular the branches are led, the more difpofed is that tree to increafe in wood; which he afcribes to the bending down of the branches impeding the circulation of the fap. Art of Gardening. Mr. Hitt in his Treatife on Fruit Trees, affirms, that if a vigorous branch of a wall-tree be bent down to the horizon or beneath it, it lofes its vigour, and becomes a bearing branch; and therefore recommends his method of nailing the branches of wall-trees, and of tying thofe of efpaliers, in an horizontal direction or ftill lower; as in this conftrained fituation there

 muft

muſt occur greater difficulty, I ſuppoſe, in the production of the new caudexes, neceſſary for the embryon progeny of buds, upwards or horizontally along the bended branch contrary to their natural habits, as well as from the compreſſion of the bark beneath the curvature of the branch, and its extenſion above it; whence more flower-ſhoots are produced, which do not require new caudexes to paſs along the bended branch; but which permit their progeny, the ſeeds, to fall upon the earth, and penetrate it with their new roots.

In Lord Stafford's gardens at Trentham I remember to have ſeen many years ago ſome ſtandard dwarf apple-trees with all their branches bent down, and fixed on a ſlight frame-work about a foot from the ground; which ſeemed to be uncommonly prolific, as a circle of white and purple flowers twenty feet in diameter on branches radiated from a center, appeared to a diſtant eye like a lunar halo, or a carpet of rich embroidery.

The greater production of fruit-buds on branches bended to the horizon muſt contribute, I ſhould ſuppoſe, to the prolific effect of training nectarine and peach-trees on tiles laid on the ground, or on the gentle declivity of a bank of earth facing the ſouth, which has lately been recommended by ſome one, whoſe name I do not recollect, who gained a patent for his diſcovery. And it is indeed probable, that both theſe modes of training fruit-trees, one of which may be called an horizontal wall-tree, and the other an horizontal eſpalier, would repay the labour of the horticultor; as they would be expoſed to a more vertical ſun in ſummer, which might more certainly ripen their fruit; and would be kept ſomewhat backwarder in the early ſpring, by the greater obliquity of the ſun-beams, and might be therefore leſs liable to injury from the vernal froſt; and when in bloſſom might eaſily be covered in the night, when neceſſary, by mats thrown over them ſupported by ſtakes with horizontal poles on them.

2. Secondly. *The twiſting a wire, or tying a waxed ſtring, round the*

the viviparous branches of a tree, induces them to become oviparous, as obſerved by Mr. Whitmill, who bound not only the viviparous ſhoots of various wall-trees with ſtrong wire, but alſo ſome of their large roots, and thus increaſed the product of his fruit. Bradley on Gardening, Vol. II. p. 155. And M. Buffon produced the ſame effect by a tight cord round the branches, which previouſly produced leaf-buds inſtead of flower-buds. Act. Paris. ann. 1738.

M. Buffon concludes from the above experiments, that an ingrafted branch bears fruit more copiouſly, and more certainly, from its veſſels being compreſſed by the callus around the ingrafted junction, which may have this effect, and at the ſame time contribute by preventing the luxuriant growth of its leaf ſhoots to render the tree of more dwarfiſh ſtature. I am informed that many dwarf apple-trees, which are now planted in garden pots both in France and England, bear much fruit, and are elegantly placed in the centre of a deſert at luxurious tables; and that the principal art of producing them conſiſts in ingrafting them three or four times, ſcion on ſcion; ſo that the ſtem is compreſſed by the callus of three or four ingraftments before the branches are permitted to divaricate; and the trees are thus rendered beautiful dwarfs.

The effect of thus compreſſing the bark by a wire, or a cord, or by the callus round the junctures of the ingrafted ſcions, is undoubtedly accompliſhed by the increaſed difficulty oppoſed to the production of the caudexes for each new embryon leaf-bud, as above explained, and the conſequent generation of flower-buds inſtead of them.

3. Thirdly. *The wounding, or breaking a viviparous branch, or cutting away a ring of the bark, as of pear-trees, or a ſemi-cylinder of the bark of other fruit-trees, induces them to become oviparous.*

Where young trees diſcover too great vigour, Mr. Lawrence adviſes to cut the moſt vigorous ſhoots two parts in three through, leaving a large notch, that the wound may not heal too ſoon; which he adds will both render them fruitful, make them more readily conform

form to the wall or efpalier, and preferve fuch as are dwarfs from too much afpiring in very ftrong branches, efpecially of pears; he recommends two or more fuch incifions to be made in the fame branch.

Another method he propofes is to break the too vigorous branches half through with the hand, which he has practifed with fuccefs in apricots and peaches, when the branches were formed directly forward from the wall, and thefe branches have continued feveral years to bear fruit, though fome have occafionally died by effufing gum; and though thefe incifions and breaking the branches may be performed at any time of the year, he prefers the fpring on account of the wet or froft of winter. Art of Gardening.

A complete cylinder of the bark about an inch in height was cut off from the branch of a pear-tree againft a wall in Mr. Howard's garden at Lichfield about five years ago; the circumcifed part is now not above half the diameter of the branch above and below it, yet this branch has been full of fruit every year fince, when the other branches of the tree bore only fparingly. I lately obferved, that the leaves of this wounded branch were fmaller and paler, and the fruit lefs in fize, and ripened fooner than on the other parts of the tree; and another branch has the bark taken off not quite all round with much the fame effect.

The theory of this curious vegetable fact receives great light from the foregoing account of the individuality of buds. A flower-bud dies when it has perfected its feed, like an annual plant, and hence requires no place on the bark for new caudexes to pafs downwards; but on the contrary leaf-buds, as they advance into fhoots, form new buds in the axilla of every leaf; which new buds require new caudexes to pafs down the bark, and thus thicken as well as elongate the branch. Now if a cylinder of the bark be deftroyed, many of thefe new caudexes cannot be produced; and thence more of the buds will be converted into flower-buds.

In

In this curious circumſtance the caudexes of the buds of the tree above the decorticated part ſeem to have emitted ſhort radicles into the alburnum ; the veſſels of which muſt thus have acted as capillary tubes between the upper and lower caudexes of thoſe buds ; as capillary tubes will raiſe water by the attraction of their internal ſurfaces nearly to their ſummits, when they are not too high in proportion to their diameter ; but water will in no caſe flow over their ſummits, but will always ſtand with a concave ſurface below the uppermoſt rim of the tube, in which ſituation it may readily be abſorbed by vegetable radicles; and may be ſupplied from beneath by the ſap-juice raiſed by the vegetable action of the abſorbent veſſels of the caudexes, whoſe radicles terminate in the earth.

It is cuſtomary to debark oak trees in the ſpring, which are intended to be felled in the enſuing autumn ; becauſe the bark comes off eaſier at this ſeaſon ; and the ſap-wood, or alburnum, is believed to become harder, and more durable, if the tree remains till the end of ſummer. The trees thus ſtripped of their bark put forth ſhoots as uſual with acorns on the ſixth, ſeventh, and eighth joints, like vines ; but in the branches I examined the joints of the debarked trees were much ſhorter than thoſe of other oak-trees, the acorns were more numerous, and no new buds were produced above the joints which bore acorns. From hence it appears, that the branches of decorticated oak-trees produce fewer leaf-buds, and more flower-buds. And ſecondly, that the new buds of debarked oak trees continue to obtain moiſture from the alburnum after the ſeaſon of the aſcent of the ſap in other vegetables ceaſes ; which in this unnatural ſtate of the debarked tree may act as capillary tubes, like the alburnum of the ſmall debarked cylinder of a pear-tree above mentioned ; or as the veſſels of the alburnum may not yet have loſt their vegetable life, they may continue to abſorb ſap-juice or water from their radicles, and carry it to the buds at the ſummits by their ſpiral contractions as in the bleeding ſeaſon.

It

It is probable, that if oaks were debarked in the fummer, that much fewer leaf-buds would appear amidft the flower-buds; becaufe many of the latter muft be advanced too far, when the trees are debarked in the fpring, to be converted into flower-buds by preventing the production of their caudexes, or by impeding the afcent of the nutritive fap-juice; which in thefe trees is lodged principally I fuppofe in the alburnum, as fpoken of in Sect. IX. 2. 8. On the fame account, when much fap-juice is taken in the vernal months from the birch or maple for the purpofes of making wine in this country, or fugar in America, I am informed, that no great difference occurs in the refpective numbers of flower-buds or leaf-buds, which then fucceed; but that the general luxuriance of the tree is diminifhed; which evinces, that for the defign of generating more flower-buds and fewer leaf-buds by partial decortication, it fhould be performed about Midfummer.

The cylindrical or femicylindrical decortication of a large root of a tree, as well as of a branch, is faid to anfwer the purpofe of increafing the production of fruit-buds by leffening the number of leaf-buds; but may be fubject to two inconveniences; firft, that the wounded root being near the furface of the ground may be liable to rot like the bottoms of hedge-ftakes; or like timber, which is kept in moift cellars; or the pofts of wooden bridges, which are alternately expofed to water and to air. A fecond inconvenience may occur from terreftrial infects having accefs to the alburnum of the root, which is often full of fweet fap-juice to invite them, and is otherwife generally defended by an acrid rind.

The parts of a tree immediately below a decorticated or a ftrangulated branch or root will generally become viviparous, and will thence be faid to be increafed in vigour; that is, it will produce new leaf-buds, and thofe of a luxuriant appearance; becaufe the injury of the bark of the branch or root will prevent the parts above from receiving fo much of the nutritive fap-juice, as in their found ftate;

ſtate; and conſequently the parts beneath will poſſeſs more of it; and alſo becauſe theſe new buds are generated from a lower part of the caudex, and will thence be a few years before they will acquire that maturity, or puberty, which is neceſſary for the generation of flower-buds, or the production of a ſexual or ſeminal progeny; whence by ſtrangulating or decorticating the alternate branches of a pear-tree they will bear for ſix or eight years; and the other alternate ones will become in the ſame time ſtrong and vigorous, ready to undergo a ſimilar operation, when the former ceaſe to be of further uſe; but the fruit will become ſmaller in ſize, though in greater number, and ripen earlier in the ſeaſon.

In the ſame manner new root-ſcions are ſaid to be produced by ſtrangulating a branch of a root near the ſurface with a tight ſtring, or by ſlitting a root near the trunk, Evelyn's Sylva; as in theſe caſes the aſcent of the ſap-juice is impeded, and the part below becomes viviparous, or produces new leaf-buds for the reaſons mentioned in the laſt paragraph; as is frequently ſeen where the end of a branch is lopped, or beneath the ſcar of the junction of an ingrafted ſcion. On the ſame account it is not uncommon to ingraft with ſucceſs on roots taken out of the ground, and afterwards replanted; as the robinia on the root of acacia, and any other apples on the roots of the ſuckers of bur-apple, or codling, mentioned in Sect. IX. 3. 5.

For the ſame reaſon the roots of ſome plants, which are otherwiſe not eaſily propagated, will ſhoot up buds; if a part of them next the ſtem of the plant be half cut through, or raiſed out of the ground, and expoſed to the air; as in pyramidal campanula, and geranium lobatum. And for the ſame reaſon the lateral branches of numerous ſhrubs, as well as of herbaceous plants, will put forth roots, when they are bent down into the ground, if they are previouſly wounded to prevent the free ſupply of the vegetable nutriment in its uſual courſe, as in laying carnations, dianthus.

A method of converting the viviparous branches of pear and apple trees into oviparous branches is defcribed by Mr. Fitzgerald in the Philofph. Tranfact. Vol. LII. and feems to be fuperior to the exfection of a cylinder of the bark above mentioned; as the alburnum is not left naked after the operation. In the month of Auguft he made a circular incifion round the principal branches of feveral pear-trees, apple-trees, plum-trees, and cherry-trees, near the ftems of each, quite through the bark. About three or four inches higher he then made another incifion round the bark, and then a perpendicular one, joining thefe two circular ones, and feparated the cylinder of bark nicely from the wood, covering it, and the bare part of the wood, from the air for about a quarter of an hour, when the wound began to bleed. He then replaced the bark with great exactnefs, and bound it round rather tightly with bafs, fo as to cover the wound entirely, and half an inch above and below the circumcifions.

In about a month the bark began to fwell above and below the bandages, he then unbound them, and found the parts quite healed. He rebound them flightly with bafs, and let them remain fo till the beginning of the next fummer, when he again took off the bandages, and found them all healthy; and every one of them bore plentifully that feafon, though it was in general reckoned a fcarce fruit year.

He treated two young pear-trees in this manner, which never had yet had any bloom; on one of them he operated on the main arms, and on feveral of the lefs branches from thofe main arms; and on only one of the main arms of the other. The firft, he fays, bore a furprizing quantity of fruit in the next fummer; and the circumcifed arm of the other bore a moderate quantity; though no other part of the tree had any appearance of bloom.

Mr. Fitzgerald afterwards took a cylinder of the bark from the branches of two young apple trees about the fame fize, as exactly as he could by meafure; and changing them, bound them each on the other tree. The bark of one had a leaf-bud and two apples growing on it; the barks of both of them healed perfectly, the leaf-bud put forth

forth leaves, and the apples remained on and ripened; and both the branches bore fo plentifully, that one broke with its load, and it was neceffary to prop the other.

The theory of the fuccefs of thefe curious experiments confirms that delivered above concerning the fcars made by the junction of ingrafted fcions with the ftocks; and it is probable, that three or four circular incifions through the bark on viviparous pear or apple trees, or a fpiral incifion, as defcribed in Sect. IX. 2. 8. might anfwer the purpofe without detracting and replacing the bark; as fcars or callous circles would be thus produced, which might render it more difficult for the new caudexes of the embryon leaf-buds to be generated, or their parts united, and confequently increafe the number of flower-buds.

Mr. Fitzgerald further obferves, that he changed cylinders of the bark with equal fuccefs of nectarine and peach trees; and that the branches thus operated upon were retarded in their general growth; which coincides with the idea of repeatedly grafting one fcion above another on the apple-trees defigned for dwarfs to be fet in garden pots, as defcribed in No. 2. 2. of this Section.

4. *The tranfplanting a viviparous fruit-tree, or deftroying fome of its roots before Midfummer, or the confining its roots in a garden pot, or on a floor of bricks beneath the foil, will induce it to become oviparous.*

Mr. Knight, in his treatife on the Culture of the Apple and Pear, p. 83, has the following paffage. "In the garden culture of the apple, where the trees are retained as dwarfs or efpaliers, the more vigoroufly growing kinds are often rendered unproductive by the exceffive, though neceffary, ufe of the pruning knife. I have always fucceeded in making trees of this kind fruitful by digging them up, and replacing them with fome frefh mould in the fame fituation. The too great luxuriance of growth is checked, and a difpofition to bear is in confequence brought on." The fame obfervation was made by Mr. Lawrence, who took up trees which were too vigorous;

that is, which produced viviparous buds inſtead of oviparous ones, and replanted them to render them fruitful. Art of Gardening. Lond. 1723.

In tranſplanting trees for any purpoſe it may be obſerved, that they ſhould not be replanted deep in the ſoil, ſince the moſt nutritive or ſalubrious parts of the earth are thoſe within the reach of the ſun's warmth, of the deſcending moiſture, and of the oxygen of the atmoſphere. And as the root-fibres of trees, like thoſe of ſeeds, always grow towards the moiſteſt part of the ſoil, as the young ſhoots and leaves grow towards the pureſt air and brighteſt light; it follows, that the root-fibres ſeldom riſe higher in the ground than they were originally ſet, and ſeldom elongate themſelves even perfectly horizontally; ſo that when a fruit-tree is planted too deep in the earth, it ſeldom grows with healthy vigour, either in reſpect to its leaf-buds or its flower-buds.

This curious effect cannot be produced by generally debilitating the tree from its want of due nouriſhment; becauſe it is ſaid to ſucceed beſt in very good ſoil, or by the addition of new garden mould, as before directed; but by rendering more difficult the production of radicles from the caudexes of the embryon leaf-buds; which deſcend to the fineſt ramifications of the old roots, and elongate themſelves beyond the extremities of their ultimate fibrils; a great number of which roots being torn off by tranſplantation, or compreſſed in a garden pot, the production or progreſs of many of the new radicles muſt be impeded or prevented; and the numerous caudexes of new leaf-buds be in conſequence formed with greater difficulty, whence an increaſed tendency to generate flower-buds.

For the ſame reaſon if beans, vicia faba, which are but a few inches high, be tranſplanted; they do not become ſo tall, but they flower and ripen their ſeeds ſooner; becauſe they can not ſo eaſily generate new leaf-buds. The ſame occurs in frequently tranſplanting brocoli, braſſica; the plant does not grow ſo tall, but has earlier flowers,

flowers, and in greater number; and it is hence better to pluck them up, than to dig them up, for the purpofe of replanting them; as by that means more of the root-fibres are torn off, and the plants become almoft totally oviparous.

It is well known, that the veffels of animal bodies are lefs liable to bleed, when they are torn afunder, than when they are cut with a fharp inftrument; as their diameters are contracted, or their internal furfaces brought into contact with each other, in the act of extending them, till they break. Thus if the navel-ftrings of new born animals are cut inftead of torn, they are liable to bleed to death; and there is a remarkable cafe of a miller's fervant, who had his arm and fhoulder bone, or fcapula, torn off in a windmill without much lofs of blood. This is mentioned to fhew, that it may alfo be better to tear up roots, which are tranfplanted for this purpofe, than to dig them up; as they may thence effufe lefs vegetable blood, and in confequence be lefs weakened by the operation.

In tranfplanting ftrawberries many of the roots being torn off, fewer leaf-buds, and confequent wires, are produced from the difficulty, which their embryon caudexes find in producing new radicles over the old ones to fupply nutriment to the wires; till they bend down and protrude roots into the ground at their other extremities; whence a greater number of flower-buds are generated; on this account the roots of ftrawberries fhould generally be tranfplanted, or new ones from the wires fhould be cultivated, every third or fourth year, to prevent the too luxuriant growth of their wires; or a fimilar difficulty of producing wires or leaf-buds may be effected by crowding the roots of ftrawberries together, as fome gardeners recommend; but I fuppofe by thefe means the fruit may become fmaller from fcarcity of nutriment, though more numerous.

A floor of bricks, or of ftone, extended about two feet deep beneath the roots of wall trees, has been practifed in fome gardens from an idea, that the roots fhot themfelves too deep into fome unwhole-
fome

ſome ſtratum of earth ; and it has been obſerved, that the trees became better fruit-bearers. In ſome ſituations it is poſſible, this might be the cauſe of the new prolific property of the trees ; but I ſuſpect it has occurred generally from the difficulty oppoſed to the number and elongation of the root-fibres, and conſequently to the generation of the new caudexes of the embryon leaf-buds ; whence a greater production of flower-buds enſued.

In ſimilar manner it is aſſerted by one of the Linnean ſchool in the Amœnitates Academicæ, that ſome bulbous rooted plants, which ſeldom produce ſeeds in Sweden, will produce prolific ſeeds, if their roots be confined in a garden pot, till they crowd each other ; as thoſe of the lily of the valley, convallaria. And that the orchis will bear prolific ſeeds, if the new root early in the ſeaſon be ſevered from the old one, which has put up the flower-ſtem. This muſt occur in the former caſe from the difficulty, which the plants find to generate new offsets at their roots, which are their viviparous progeny; and in the latter caſe from the new offset being deſtroyed ; whence in both ſituations more nutriment is expended on the flower.

On the ſame account it is probable, that confining the roots of cucumbers and melons in ſmall garden pots would ſtop the too luxuriant growth of their leaf-buds, and render them ſooner oviparous, if care was taken to ſupply them with water more frequently, and with ſufficient nutriment by mixing with the water ſome of the carbonic black fluid, which has drained from a manure heap.

5. *If the central viviparous branches of a plant be cut away or ſhortened, the lateral ones will ſooner or more completely become oviparous.* 1. There are many very ſmall buds on the lower parts of large branches, which do not ſeem to grow to maturity, and in conſequence produce neither new leaf-buds nor new flower-buds. There are other lateral ſhoots on many trees, which only puſh out a few inches, and are called ſpurs, and which bear fruit the ſucceeding ſummer at their extremities. In many other plants the lateral branches are oviparous,

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except at the extremity, which is terminated with a viviparous bud; while the central branches continue long to generate only a viviparous progeny, as in vines and melons.

The firſt of theſe, or the unprolific exiſtence of the buds at the bottom of large branches, may be owing in part to their feebler efforts of pullulation from the want of ſufficient ſunſhine and ventilation; and alſo in part, like the ſpurs, and other lateral branches, to the difficulty they encounter in producing the embryon caudexes of new leaf-buds along the trunk; which is already occupied by thoſe of the more vigorous vegetation of the central branches, which poſſeſs a greater ſhare of ſunſhine and ventilation.

But the principal cauſe, which renders the ſpurs and lateral branches oviparous, reſults from the reſiſtance the embryon caudexes of leaf-buds experience by the curvature of the lateral branch, where it joins the trunk, and the conſequent coarctation of its veſſels, added to the difficulty every lateral bud has to encounter from its own curvature at its exit from the parent twig; on which laſt account the central bud at the extremity of an oviparous branch is generally viviparous, becauſe it has not any curvature at its exit. All this correſponds with the fact above deſcribed, that when the viviparous arms of wall-trees are bent down to the horizon, they become oviparous. See No. 2. 1. of this Section.

2. What then happens in all theſe ſituations when the central parts are cut away or ſhortened? Firſt the dwarf buds at the bottom of theſe large viviparous branches, which are in part cut away, will find more room to puſh down the embryon caudexes of new leaf-buds; and will produce a viviparous progeny; and thoſe at the bottom of oviparous branches, which are ſhortened by cutting off their viviparous extremities, will alſo now pullulate, and produce flower-buds for the ſucceeding year, owing to the derivation of ſome of that nouriſhment to them, which would otherwiſe have been expended on the ſummit-bud. Secondly, the ſpurs will generate an oviparous progeny,

geny, but will acquire more nutriment, becaufe all the veffels of plants inofculate, as mentioned in Sect. IX. 2. 10. and will thence produce larger fruit, and more certainly ripen it. Thirdly, the other lateral branches will receive more nourifhment, and become more vertical, and will thence find lefs oppofition to the production of the caudexes, both of their flower-buds and leaf-buds; either of which may become ftronger or more numerous according to the greater or lefs inclination of the branches to the horizon; and both of them may be more vigorous properly fpeaking; that is, they may become larger leaf-buds, or larger flower-buds, than others of the fame tree.

3. Thus in the management of MELONS, which would grow into branches much too extenfive for the artificial glafs-frames of our climate, and would not have time to ripen their later fruit in our fhort fummers; it is neceffary firft to check the vigour, properly fo fpeaking, of the whole plant. This is done by wafhing the feed from the ripe fruit, which fhould naturally contribute to nourifh it; and by keeping the feed four or five years, that the mucilaginous nutriment depofited in the cotyledons may alfo be in fome degree impaired; it is alfo probable, that confining the roots of melons and cucumbers in garden-pots, if they were well fupplied with nutriment, warmth, and water, might be advantageous for this purpofe.

Secondly, as foon as the leaf appears an inch in diameter, experienced gardeners pick out the central bud, which caufes an oviparous, though a more vigorous, lateral fhoot; which therefore fooner bears fruit, and that of a larger kind; as it acquires more nourifhment from the deftruction of the central one.

And as thefe lateral branches are liable to produce other viviparous fhoots at their extremities, after they have generated lateral flower-buds, it again becomes neceffary to pinch off the viviparous extremities of them, not only to accommodate them to the fize of the glafs-frame, but alfo to fupply them with more nutriment, which would otherwife have been expended on the viviparous fummit.

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The central bud, or ſummit, of the lateral branches, is generally viviparous, as well as of the central branches; becauſe the embryon caudexes of its new offspring are oppoſed in the production along the bark by only one curvature at the inſertion of the branch into the trunk; whereas the lateral buds of the lateral branches have the progreſs of the embryon caudexes of their new buds oppoſed by two curvatures, one of the bud to the branch, and another from the branch to the trunk.

There is another reaſon, why the lateral buds of many plants produce flowers ſooner than the ſummit; which is, that the lateral buds of thoſe plants, where the pith of the upright central ſhoot is not divided, are propagated from the central ſhoot, and are therefore one generation older; and have thus acquired the maturity neceſſary for amatorial reproduction. In other plants, where the pith of the ſtem is divided at every joint, the ſummit bud has been preceded by more generations, and is therefore more mature for the purpoſe of producing flowers, than the lateral ones, as in a ſtem of wheat; and probably in the artichoke, and on the ſpurs of ſome fruit trees, as of pears.

4. It was obſerved in Sect. IX. 3. 1. that in the ſtems of wheat three or four joints are formed above each other previous to that, which bears the ear; and that in many other annual or biennial plants two or three viviparous lateral ſhoots occur, as in artichoke, cinara; and ſalſafi, tragopogon, before the central one flowers. The ſame happens to the vine-ſhoots; two or three joints with a leaf and a viviparous bud at each are always firſt produced; and as each of theſe have a diviſion of the pith between every joint, as remarked in Sect. I. 8. I ſuppoſe, that theſe joints are ſeparate plants growing on each other like the joints of the ſtem of wheat; and that hence in vine-ſhoots three or four ſucceſſive generations of leaf-ſhoots muſt exiſt, before the new ſhoot can attain ſufficient maturity to form a flower; as the amatorial generation of ſeeds was ſhewn to require

higher animation, if it may be fo called, than the lateral generation of leaf-buds. The fame mode of growth occurs in the young fhoots of oaks, and which is thus curioufly accounted for.

The lateral branches of many mature trees, though they bear flower-buds on their fides, are generally terminated with a leaf-bud, as above explained; but it happens in fome of them, and particularly to vines, that after two or three flower-buds are produced on a lateral branch, that it fhall proceed to grow in length, and to produce leaf-buds at every joint above the flower-buds, as well as at the fummit; which may be thus perhaps fatisfactorily explained. After the third, and fourth, and fifth joints of a new lateral fhoot have generated flowers, which require few or no more caudexes; room enough is left on the bark of the fhoot for thofe above them to acquire the numerous new miniature caudexes of embryon leaf-buds, and where the new caudexes of embryon buds can eafily be produced along the bark, and fufficient nutriment is fupplied; all vegetables are more liable to propagate themfelves by buds than by feeds.

Hence in the management of VINES, as well as of MELONS, it is ufeful at two or three joints above the laft bunch of fruit to pinch off the viviparous end of the new branch, not fo much to accommodate the length of it to the houfe, as to fupply the growing fruit with more nourifhment from the inofculations of the veffels of the caudexes of thefe viviparous buds, which are now cut off, with thofe of the oviparous ones, which remain.

A curious vegetable fact, which appears in the culture of VINES in hot-houfes here prefents itfelf to our notice. When a vigorous fhoot advances without producing fruit-buds at the third or fourth joint, it is frequently permitted to grow in length to above twenty feet; but at every joint the new or fecondary bud is pinched off, either foon after its appearance, or after it has fhot out one or two joints. By this management of permitting the central fummit of the fhoot to grow till Auguft or September, the eyes, whofe buds have been

9 pinched

pinched off, do not put out a frefh during that fummer; but new buds are formed at each eye, which germinate the next fummer, and almoft all of them produce fruit.

If however fome of the fhoots in the bofom of thefe leaves are pinched off too foon after their appearance, they are occafionally liable to generate new leaf-buds, which fhoot out afrefh from the fame eye; and it is faid, that thefe eyes, which have thus produced two leaf-buds in fucceffion in one fummer, will not generally produce buds of any kind in the fucceeding fummer; for as feveral of thefe joints in vigorous vines bear two or three buds from the fame eye at the fame time, fo others bear them in fucceffion.

The theory of thefe important facts may not be eafy to inveftigate; it is commonly fuppofed, that pinching off the lateral fhoots at every bud of a new vine-branch ftrengthens the next year's expected bud, by not expending fo much nutritive juice; and that giving the vines a fortnight's artificial heat, after the fummer heat leffens, ripens the wood for the production of the next year's fruit; but thefe are words, I imagine, without accurate ideas. I fuppofe, when each lateral fhoot of this year's branch of a vine is pinched off, that its caudexes, which had already formed a part of the bark, coalefce; and may thus render it more difficult for the caudexes of the fucceeding embryon bud in the fame eye, which is to be expanded next fpring, to be produced along the bark, by having previoufly occupied the fituation which thofe new caudexes would require; and that thus the fecondary buds of thefe eyes become flower-buds, which might otherwife have been leaf-buds.

The continued heat a week or two above the ufual time of fummer, which is faid to ripen the wood, may contribute to dry and harden it, as well as to forward the growth of the buds; and thus both to render the protrufion of embryon roots more difficult, and confequently to produce flower-buds, and thofe of a larger kind.

Whether a fimilar method to this practifed on vines could be applied with advantage in the management of other fruit-trees is a circumſtance of great importance, and can only be determined by experiment. But as the firſt foliage of euonymus is generally deſtroyed by inſects in this country, and yet a ſecond growth of foliage is produced; and as I witneſſed laſt year, that the whole firſt leaves of an apple-tree were deſtroyed, as was believed, by lightning, and which yet put forth an entire new ſet of leaves in a few weeks; is there not reaſon to conclude, that if the leaf-buds were picked out early in the ſeaſon from a ſtrong ſhoot of peach or apricot, either new leaf-buds might be produced in that ſummer, or flower-buds in the ſucceeding one, as happens to the vine-ſhoots above deſcribed; and that our wall-trees might be thus rendered more certainly prolific. And laſtly, might not the clipping out with fine ſciſſars the extremities of young vine-ſhoots, which would otherwiſe be barren ones, convert ſome of their tendrils into bunches by thus ſupplying them with additional nutriment, by preventing its expenditure in the elongation of the viviparous branch? This experiment might be the more readily tried, as ſome aſſert, that the barren buds may be diſtinguiſhed from the prolific ones by their form before they expand.

6. *Arts of producing flower-buds.*

The following quotation, partly from the Botanic Garden, Vol. I. Canto 4. l. 465, may amuſe the reader, and conclude the ſecond part of this Section.

> If prouder branches with exuberance rude
> Point their green germs, their barren ſhoots protrude;
> Lop with ſharp ſteel the central growth, or bind
> A wiry ringlet round the ſwelling rind;
> Biſect with chiſel ſharp the root below,
> Or bend to earth the inhoſpitable bough.
> So, while oppoſed, no embryon leaf-bud ſhoots
> Down the reluctant bark its fibre-roots;

New germs ſhall ſwell with amatorial power,
And ſexual beauties deck the glowing flower;
While the clos'd *petals* from nocturnal cold
With ſilken veil the virgin *ſtigma* fold,
Shake into viewleſs air the morning dews,
And wave in light their irideſcent hues;
With graceful bend the *anther* by her ſide
Shall watch the bluſhes of his waking bride,
Give to her hand the honey'd cup, or ſip
Celeſtial nectar from her ſweeter lip,
Hang in wild raptures o'er the yielding fair,
Love out his hour, and leave his life in air.

III. TO PERFECT AND ENLARGE THE FRUIT.

It is believed by ſome of the Linnean ſchool, that flower-buds or leaf-buds may be converted into each other in the early ſtate of their exiſtence, as mentioned in Sect. IX. 2. 8. It is indeed probable, that either a flower-bud or leaf-bud may be generated inſtead of each other reciprocally, before either of them exiſts; but after either of them has obtained a certain degree of maturity, ſo as to be diſtinguiſhed by its form being more pointed or more ſpherical; I ſuſpect no addition or detraction of nutriment, or of the facility of the production of its embryon caudexes down the bark and radicles beneath can change its deſtination.

1. *Shorten the oviparous branches, when the leaves fall off, by pruning their viviparous ſummits, and cut away the root-ſuckers.* The ſummits of the lateral branches, as well as the erect ones, are furniſhed generally with viviparous buds; which in many wall-trees ſhould be cut off, after the leaves fall in autumn; that more nutriment may be derived to the fruit-buds, which may occaſionally become ſomewhat enlarged during the milder days of winter; as they are now certainly too far advanced to be changed into leaf-buds; and

if this pruning be deferred till late in the winter months, the flower-ubds will not be quite ſo forward, as if it be performed earlier. For the ſame reaſon the root-ſuckers alſo ſhould be cut away in the autumn, that all the nutriment, which they would otherwiſe expend, may be derived to the flower-buds, and induce them early to enlarge themſelves.

2. *Pinch or rub off all uſeleſs viviparous buds in the ſpring or ſummer, as they occur.* In thoſe trees where the fruit-buds ariſe on the new leaf-ſhoots along with the leaf-buds, and cannot therefore be ſooner diſtinguiſhed or approached, as in figs and vines, the ſummit leaf-buds ſhould be pinched off two joints above the fruit-buds, as ſoon as they appear, that more nutriment may be conveyed to the fruit-buds. See No. 3. 4. of this Section.

And in the hardier wall-trees the new leaf-buds, which appear during the ſpring and ſummer months in wrong places, where they cannot be trained properly againſt the wall, or where they are too numerous, ſhould be rubbed or pinched off, as they occur; whence more nouriſhment will be derived to the ripening fruit, and to thoſe new leaf-buds which are to remain to produce future flower-buds.

And if the new buds, which are ſeen in their young ſtate in the axilla of the leaves of the new ſhoots, were picked out by the point of a knife, or pinched off, where they grow long enough for that purpoſe, as the ſecondary ſhoots of vines in grape houſes are pinched; it might probably induce thoſe eyes to produce flowers in the ſucceeding year, as ſpoken of in No. 2. 5. of this Section, as well as contribute to enlarge the preſent fruit by the expenditure of leſs nutriment on the leaf-buds, an idea well deſerving the teſt of experiment.

In the ſame manner in the cultivation of melons and cucumbers after the central bud is pinched off, as mentioned above, No. 2. 5. the viviparous extremities of the lateral branches ſhould be alſo deſtroyed, as ſoon as a ſufficient number of female flowers are impregnated;

that

that a greater ſhare of nutriment may be derived to them, inſtead of crowding the frame with new branches, whoſe fruit-buds would be too late to ripen in our ſhort ſummers.

3. *Thin all thoſe fruits, which are too numerous; pluck off apricots, peaches, gooſeberries; and cut out many grapes from each bunch with ſciſſars.* By the inoſculation of the veſſels of vegetables mentioned in Sect. I. 3, when any parts of a tree are deſtroyed, thoſe in their vicinity become more vigorous. On this account when part of the fruit is taken away as early as may be, the remaining part acquires more nutriment. Add to this, that, where fruit is crowded, ſome of it becomes precluded from the ſun and air, and in conſequence does not perfectly ripen, and is liable to become mouldy; for mucor is a vegetable production, which like other fungi does not require either much light or air, as appears from the growth of ſome funguſſes in dark cellars, and of common muſhrooms beneath beds of ſtraw, as mentioned in Sect. XIII. 1. 4.

4. *Prevent the production of new leaf-buds.*

In ſome pear trees the whole of the bloſſoms become ſterile, and fall off without any apparent injury from cold, and this for many ſucceſſive years. The ſame occurs ſometimes to cheſnut trees, æſculus pavia, after the flower the fructification entirely falls off; ſome of theſe might be male flowers, as Miller obſerves, but the whole could not be ſuch. The ſame happens very frequently to the fig-trees of this climate, ſometimes the whole crop falls off, when they are about the ſize of filberts; that is, while they are ſtill in flower, which though concealed within the fig, muſt precede the ſwelling of the ſeeds, whether theſe be impregnated or not.

A correſpondent fact occurred to me a few years ago. I had ſix young trees of the Iſchia fig with fruit on them in pots in a ſtove. On removing them into larger boxes the figs fell off, which I aſcribed to the increaſed vigour of the plants; as they protruded very vigorous ſhoots occaſioned by the accumulation of new ſoil round their

roots.

roots. Perhaps theſe plants might rather be ſaid to have been in flower than in fruit, and perhaps theſe flowers were all male ones only, or accompanied only with imperfect female ones?

Whence I conclude, that about the ſeaſon when the corals of theſe flowers with their ſtamens and ſtigmas die, the trees generate and nouriſh too many new leaf-buds, owing to the facility with which they can produce the new caudexes of theſe young buds down the bark; and that by the whole of the vegetable ſap-juice being derived to the new buds for their preſent growth, or to form reſervoirs for their future growth, the pericarp and ſeeds, whether impregnated or not, are deprived of their due nutriment and fall off. See Sect. XVI. 1. 4.

Hence I propoſe to tie waxed thread or fine wire round the twigs of pear-trees, which have uſually miſcarried, as ſoon as they are in flower, ſo as to compreſs, but not ſo as to ſtrangulate them; or to wound the bark by a circular or ſemicircular inciſion, which might counteract their facility of procreating new leaf-buds; which I ſuſpect would be more effectual in preventing the flowers from falling off, than pinching off the new leaf-buds, as they appear; which is recommended by Dr. Bradley in the management of fig-trees, and is done to vines in hot-houſes; but which I found to be ineffectual on many fig-branches both in the natural ground and in pots, and aſcribed its failure to the continuance of the efforts of the fig-tree to produce new leaf-buds; whereas in vines, I ſuppoſe, the grapes would ripen, whether the new leaf-buds remain or are deſtroyed. See No. 3. 2. of this Section.

Pontedera obſerved, that in the iſlands of the Archipelago ſome fig-trees bear in the ſpring many male flowers, and few female ones, the former of which fall off; and that they bear a ſecond crop chiefly of female flowers in the autumn, which ripen in the enſuing ſpring. Anthologia. Can this occur in the fig-trees of this country?

Other figs are ſaid not to ripen but to fall off before their maturity, unleſs unlefs they be wounded by infects in their caprification, or punctured by a ftraw. A further inveftigation of this fubject is much wanted to propagate figs with fuccefs in this climate. See Botanic Garden, Vol. II. note on caprificus. See alfo Milne's Botan. Diction. Article caprification.

5. *Give additional moifture, manure, and warmth, during the early part of the growth of fruit.* By additional moifture the fruit becomes larger; in hot-houfes this may be effected two ways, one by watering the earth on which the vegetables grow, and another by producing fteam by watering the warm flues or floors; which will afterwards in the colder hours be again condenfed, and fettle in the form of dew on the fruit and leaves.

By fupplying vegetables as well as animals with an abundancy of fluid, they are liable to increafe in bulk, both becaufe the external cuticle, which confines the growth of both of them, becomes relaxed, as is feen in the hands of thofe women, who have many hours been employed in wafhing; and alfo becaufe the cutaneous abforbent veffels will thus imbibe more fluid from the external furface; and the cellular abforbents will therefore imbibe lefs from the internal cells, and confequently more mucus or fat will remain in them.

Thus in Lancafhire, where premiums are given for large goofeberries, I am told, that fome of thofe, who are folicitous for the prizes, not only thin the fruit of a goofeberry-tree, fo as to leave but two or three goofeberries on a branch, but then by fupporting a tea-faucer under each of thefe goofeberries, bathe it for fome weeks in fo much water as to cover about a fourth part of it; which they call fuckling the goofeberry.

In fome parts of the Carnatic, where rice is cultivated, they are faid not to derive the water on it, till it is in flower; becaufe that would induce the ftem to fhoot too luxuriantly, like our wheat-crops in wet-feafons; but, as foon as it is in flower, they find it expedient to flood it with water for the purpofe of filling and enlarging the

 ears,

ears, (Communications to Board of Agriculture, Vol. I. p. 355,) which it may effect both by relaxing the cuticle of the grain, and preventing the too great internal abforption of the mucus or ftarch depofited in the cells of it; and laftly by fupplying it with more nutriment.

There are two circumftances to be attended to in giving water to plants; which are, not to water them during the hot part of the day in fummer, nor in the evenings of fpring, when a froft may be expected; in both thefe circumftances we may be faid to copy nature, as rain is generally preceded by a cloudy fky, and is never accompanied by froft; though that fometimes follows it, and is then very injurious to vegetation.

When plants have been long ftimulated by a hot funfhine into violent action, if this ftimulus of heat be too greatly and too fuddenly diminifhed by the affufion of cold water, or by its fudden evaporation, their veffels ceafe to act, and death enfues; exactly as has too frequently happened to thofe, who have bathed in a cold fpring of water after having been heated by violent and continued exercife on a hot day. When fevere froft follows the watering of plants, they are rendered torpid, and die by the too great and fudden diminution of the ftimulus of heat; which is equally neceffary to the activity of vegetable as to animal fibres; and in fome inftances the circulation of their fluids may be ftopped by the congelation of them; and in others their veffels may be burft by the expanfion attending the converfion of water into ice; or laftly, by the feparation of their different fluids by congelation. See Sect. XV. 4. 1.

When an addition of manure can be procured, as where the black carbonic juice from a dunghill mixed with water, or foap-fuds, which have been ufed in wafhing, can be employed inftead of water alone; it muft undoubtedly add to the nutriment, and confequently enlarge the fize of the fruit by that means alfo, as well as by the additional water.

Where too much moifture is given without at the fame time an addition of warmth, fome inconveniences are liable to occur, as a lefs aromatic and faccharine flavour of the fruit. When therefore fruits become nearly ripe, lefs water fhould be given them, unlefs it is convenient at the fame time to increafe the heat, in which they are immerfed, as may be done in fome hot-houfes; and then the flavour of the fruit may be heightened, as well as its fize increafed, as fhewn by Mr. Baftard in the Philofophical Tranfact. who planted pine-apple plants in veffels of water, and placed thefe veffels near the top of the hot-houfe, or on the fire-flues, for the purpofe of fupplying them with a greater heat; and produced by thefe means both larger, as he afferts, and better flavoured pine apples.

On this important fubject I fhall tranfcribe his words, and fhall only add, that fteam from boiling water is now fuccefsfully ufed in fome hot-houfes for the growth both of vines and of pines, but muft require fome attention in the application of it; as it is occafionally conveyed through fmall apertures, which perforate a brick arch, which is conftructed fomewhat like the floor of a malt-kiln, where the water boils beneath the beds of bark or of foil; and is occafionally admitted into the room above, and thus fupplies moifture and heat both to the ground and to the air of the hot-houfe.

"My hot-houfe is covered with the beft crown glafs, which I apprehend gives more heat than the common fort of green glafs generally ufed for hot houfes. In the front part of the houfe, and indeed any where in the loweft parts of it, the pine-apple plants will not thrive well in water. The way in which I treat them is as follows. I place a fhelf near the higheft part of the back wall, fo that the pine-plants may ftand without abfolutely touching the glafs, but as near it as can be. On this fhelf I place pans full of water, about feven or eight inches deep; and in thefe pans I put the pine-apple

 plants,

plants, growing in the ſame pots of earth, as they are generally planted in to be plunged into the bark-bed in the common way; that is, I put the pot of earth with the pine-plant in it in the pan full of water; and as the water decreaſes, I conſtantly fill up the pan. I place either plants in fruit, or young plants as ſoon as they are well rooted, in theſe pans of water, and find they thrive equally well; the fruit reared this way is always much larger, as well as better flavoured, than when ripened in the bark-bed. I have more than once put only the plants themſelves without any earth, I mean after they had roots, into theſe pans of water, with only water ſufficient to keep the roots always covered, and found them flouriſh beyond expectation. A neighbour of mine has placed a leaden ciſtern upon the top of the back flue, (in which, as it is in contact with the flue, the water is always warm, when there is fire in the houſe,) and finds his fruit excellent and large.

" The way I account for this ſucceſs is, that the warm air always aſcending to the part, where this ſhelf is placed, as being the higheſt part of the houſe, keeps it much hotter than in any other part. The temperature at that place is, I believe, ſeldom leſs than what is indicated by the 73d degree of Fahrenheit's thermometer; and when the ſun ſhines, it is often at above 100°; the water the plants grow in ſeems to enable them to bear the greateſt heat, if ſufficient air be allowed; and I often ſee the roots of the plants growing out of the holes in the bottom of the pot of earth, and ſhooting vigorouſly in the water.

" It is not foreign to this purpoſe to mention, that, as a perſon was moving a large pine-plant from the hot-bed in my houſe laſt ſummer, which plant was juſt ſhewing fruit, by ſome accident he broke off the plant juſt above the earth in which it grew, and there was no root whatever left to it; by way of experiment I took the plant, and fixed it upright in a pan of water (without any earth whatever) on the

the ſhelf; it there ſoon threw out roots, and bore a pine-apple that weighed upwards of two pounds." Philoſ. Tranſact. Vol. LXVII.

6. *Protect the early flowers and the late fruits from froſt.* The vernal froſts are very pernicious to the early bloſſoms of apples and pears, and of all the tender wall-trees; various contrivances have been uſed to ſhelter them, as mats ſuſpended before wall-trees; which in Denmark are ſaid to be uſed to ſhelter them from the mid-day ſun, as well as from the night-froſts; both to prevent them from flowering too early, and being thence expoſed to ſeverer froſts; and becauſe vegetables ſuffer more from great cold, as well as animals, after having been expoſed to great heat, as explained in Sect. XIV. 2. 2.

Thoſe parts of vegetables, which are moſt ſucculent, ſuffer moſt from froſt, as the young tops of tender trees, as of the aſh, fraxinus, and weeping willow, ſalix babylonica; and alſo all other vegetables after having been expoſed to much moiſture, as to rain or dews; which probably may occur in part from the greater ſenſibility of the tender juicy ſummits of the preſent year's growth, and partly from the expanſion of their frozen juices, which may burſt the containing veſſels.

An important queſtion here occurs, is a low ſituation to be choſen for a garden? The greater warmth of low ſituations, and their being generally better ſheltered from the cold north-eaſt winds, and the boiſterous ſouth-weſt winds, are agreeable circumſtances; as the N. E. winds in this climate are the freezing winds; and S.W. winds being more violent, are liable much to injure ſtandard fruit-trees in ſummer by daſhing their branches againſt each other, and thence bruiſing, or beating off the fruit; but in low ſituations the fogs in vernal evenings, by moiſtening the young ſhoots of trees, and their early flowers, render them much more liable to the injuries of the froſty nights, which ſucceed them, which they eſcape in higher ſituations. Theſe fogs, which are ſeen by the ſides of rivers, and on damp plains or valleys after ſun-ſet, are converted into rime during the night. And as at at the time of thefe fogs there is generally no wind, the dew falls perpendicularly, and the rime is formed moft frequently on the upper furface of objects, which may then therefore be more readily fheltered from it than at other times, when the freezing fog is blown forwards by the wind, and the rime is formed on one fide of the branches of trees.

In fome circumftances the rime is believed to defend the vegetables on which it is formed, by the heat it gives out at the inftant of its freezing, and by covering them from the cold like fnow upon the ground; and thence the black frofts, which are not attended with rime, are faid to be more prejudicial. But where dew or mift defcends on vegetable leaves before the act of freezing commences, and is in part abforbed by them; they become more fucculent, and hence are deftroyed by their fluids being converted into ice, and burfting the veffels already diftended with more water, than they would otherwife poffefs. See Sect. XIII. 2. 2.

Mr. Bradley gives a decifive fact in regard to this fubject. A friend of his had two gardens, one not many feet below the other, but fo different, that the low garden often appeared flooded with the evening mifts, when none appeared in the upper one; and in a letter to Mr. Bradley he complains that his lower garden is much injured by the vernal froft, and not his upper one. A fimilar fact is mentioned by Mr. Lawrence, who obferves, that he has often feen the leaves and tender fhoots of tall afh-trees in blafting mifts to be frozen, and as it were finged, in all the lower parts and middle of the tree; while the upper part, which was above the mift, has been uninjured. Art of Gardening. In confirmation of this idea I well remember many years ago to have travelled fixty miles, partly in the valley of the Trent, and partly over adjacent hills, on the fixth of May; and to have obferved that the new fhoots of all the afh-trees in the vallies had their young extremities entirely turned black by the froft of the preceding night; but that on the hills they had efcaped, which I at

I at firſt aſcribed to the trees being leſs forward on the hills, but believe it was more probably owing to the greater ſucculence of thoſe in the valleys, and to their having been previouſly expoſed to the moiſture of the evening miſt.

The precipitation or adheſion of moiſture to vegetables, when miſty air is blown againſt them, is well deſcribed by Mr. White in his hiſtory of Shelborne; who obſerved on a foggy day with ſome wind, that ſo much moiſture was depoſited on a tree, that it ran down upon the ground, and filled the ruts of a lane beneath it, which was dry elſewhere. On the ſame account in the early ſpring the graſs is ſeen to become green ſooner under the ſpreading branches of trees than in their vicinity. See Botanic Garden, Vol. I. note 26.

It is hence evident, that very low and damp ſituations are not to be preferred for gardens and orchards in this climate; and that it is in all gardens an object worthy attention to protect in the early ſpring the bloſſoms and the young ſhoots from being moiſtened by the deſcending night dews; for this purpoſe ſome have put coping ſtones at the top of the fruit-walls, ſo as to project ſix or eight inches over the trees. By the ſhelter of theſe coping ſtones the deſcending dews, which would moiſten the young leaves and flowers, are prevented from falling on them, and in conſequence no rime is ſeen in the morning on theſe trees. I had once an opportunity of obſerving ſome trees beneath a projecting coping to be much ſafer in reſpect both to their fruit and foliage, than thoſe in their vicinity, and in the ſame aſpect, where there were no coping ſtones over them.

But I am informed, that after the vernal froſts have ceaſed, this kind of ſhelter is certainly injurious to the growth and perfection of the fruit; which may ariſe from the ſame cauſe, namely, the want of the ſummer night-dews to moiſten the fruit, and alſo the perpendicular ſun-beams to ripen it. On theſe accounts I have propoſed to make temporary ſheds of boards to project eight inches from the walls, to be held on by iron hooks, which might eaſily be re-

moved,

moved, as soon as the vernal frosts should cease; and in one experiment on a single apricot tree it appeared to succeed well.

From some experiments in a late volume in the Philosophical Transactions, it appears, that very much more rain was caught in glasses placed on the ground near a high church, than was caught in similar glasses on the roof of it; which evinces, that a much greater quantity of moisture exists in the lower parts of the atmosphere, and is precipitated from it, than from the higher parts; whence to protect the blossoms more effectually from the descending dews coping boards might be placed at every two feet or less above each other, with their front edges pointing upwards to the meridian sun in March, and ledges nailed on the back edges to convey the rain or dews towards the central part of the tree, where by another cross ledge at the end of each board it might be carried from the wall.

A similar inconvenience from autumnal frosts affects some of the late fruits, as figs and grapes, which might also receive advantage from replacing the coping boards in the autumn.

Another method of effectually guarding against the vernal frosts, and also the autumnal ones, is by building the garden-walls with fire-flues in them, which is now frequently practised. There is one secret necessary to be known, and well attended to, in the management of fire-flues; and that is in the first place to plant trees, which will open their flowers about the same time, against the same flue, and then diligently to observe not to put fire into this flue, till the trees, it is designed to assist, are in flower; since if the fire be applied sooner, the flowers are forwarded, and in consequence exposed to more danger from the severer frosts. One friend of mine, who diligently attends to this circumstance, assures me, that he never fails of producing a plentiful crop of excellent fruit.

And it is possible that one use of covering apricot trees, before they flower, from the mid-day sun, which is said to be practised in Denmark, may be to protract their time of flowering, and thus expose them

them to lefs danger from froft, as well as to prevent their irritability from being exhaufted by the heat, and thus caufing the night air to be more injurious to them.

7. *Fruits may be fooner ripened by wounding them, or by gathering them.* The wounds inflicted by infects on many fruits promotes their more fpeedy ripening, as well as thofe inflicted by caprification, mentioned in Sect. XIV. 3. 3. and in No. 3. 4. of this Section. It is faid that cutting the ftalk of a bunch of grapes half through, which has acquired its due fize, will expedite the ripening of it; becaufe it will then be fupplied with a lefs quantity of new juices, and the change of its acerb juices into faccharine ones, which is partly a chemical, and partly a vegetable procefs, proceeds more rapidly. See Sect. X. 8. 1. On the fame account the pears on a branch, which has had a circle of its bark cut away, will ripen its fruit fooner; and thofe annual plants, which are fupplied with lefs water than ufual, both flower fooner, and ripen their feed fooner.

To which may be added, that gathering pears from the tree before they are ripe, and laying them on heaps covered with blankets, is known confiderably to forward their ripening, by fomething like a chemical fermentation added to the living action of the fruit, which advances the faccharine procefs with greater rapidity.

I have feen apricots at table, which I was informed were plucked from the tree, and kept fome days in a hot-houfe, and thus became delicioufly ripe; in the fame manner as harfh pears ripen almoft into a fyrup during twelve or twenty hours baking in a flow oven; which occafioned the jeft of a French traveller, who on being afked on his return, what good fruit they had in England, anfwered, that the only ripe fruit he happened to tafte was the baked pear.

IV. The arts of preserving fruit, as they depend on the prevention of the chemical proceffes, which produce their diffolution, ought to be here mentioned.

1. As life whether animal or vegetable prevents putrefaction, and as many fruits exift long, after they are gathered from the tree, before they become ripe and die fpontaneoufly, and in confequence putrefy, as crabs, floes, medlars, and auftere pears. The art of preferving thefe confifts in ftoring them, where the heat is neither much above or below 48 degrees, which is the temperature of the interior parts of the earth; that is, in a dry cellar, or beneath the foil, or well covered with ftraw or mats in a dry chamber. As greater heat might make them ripen fooner, than they are wanted, by the increafed activity of their vegetable life; and froft by deftroying that life would fubject them to putrefy, when they become thawed; as perpetually happens to apples and potatoes, which are not well defended from froft. And laftly, the moifture would injure them many ways; firft by its contributing to deftroy their vegetable life; fecondly in promoting the chemical procefs of putrefaction; and thirdly by its encouraging the growth of mucor, or mould, which will grow in moift fituations without much light or air.

Too great warmth deftroys both animal and vegetable life by ftimulating their veffels into too great activity for a time, whence a fubfequent torpor from the too great previous expenditure of the living power, which terminates in death. After the death of the organization a boiling heat coagulates the mucilaginous fluids, and if continued would I believe prevent the chemical fermentation of them; and that thus both vegetable and animal fubftances might be preferved. The experiment is difficult to try, and could not therefore be of much practical utility if it fhould fucceed.

Great cold on the contrary deftroys both animals and vegetables by the torpor occafioned by the defect of ftimulus, and a confequent temporary death. Afterwards if a great degree of cold be continued, in fome cafes the expanfion of their freezing juices may burft the vegetable veffels, and thus render the life of them irrecoverable. But there is another curious thing happens to many aqueous folutions, or

 diffufions,

diffufions, which is, that at the time of congelation the diffolved or diffufed particles are pufhed from the ice, either to the centre, if the cold be applied equally on all fides, or into various cells, as mentioned in Sect. XIII. 2. 2.

This exclufion of falt is feen in freezing any faline folution in water; as common falt or blue vitriol expofed to fevere froft in a two-ounce phial are driven to the center of it. Wine, vinegar, and even milk, may be thus deprived of much of their water. Very moift clay, when expofed to frofty air, fhrinks and becomes much more folid according to the affertion of Mr. Kirwan. Mineralog. Vol. I. p. 9, the freezing water covering its furface with ice, and driving the molecules of clay nearer the centre. And laftly, the mucilage produced by boiling wheat flour in water, like book-binders pafte, if not too thick, lofes its cohefion by being frozen, the water driving, as it freezes, the ftarch from its cryftallization; and from this circumftance probably is occafioned the change of flavour of apples, potatoes, and other vegetables, on being thawed after they have been frozen.

It is neverthelefs affirmed, I think, by Monf. Reaumeur, that if frozen apples be dipped in cold water repeatedly, and the ice thus formed on their furface be wiped off, or if they be left in a large pail full of very cold water, fo that they may not thaw too haftily, they will not lofe their flavour. If this be true, and the apples will keep found fome time afterwards, it would feem that the vegetable life was not deftroyed; but that, like fleeping infects, they were reanimated by the warmth; otherwife, if the flavour be not deftroyed, and they could be immediately eaten or ufed in cookery, it is ftill a valuable difcovery if true, and might lead us to preferve variety of fruits in ice-houfes, as ftrawberries, currants, grapes, and pines, to the great advantage of fociety. See Sect. XVII. 2. 4.

As the procefs of fermentation will not commence or continue, I believe, in the heat of boiling water, or 212; and as this degree of heat can be eafily preferved by fteam, or by the vicinity of veffels containing boiling water; it is probable, that fruits for the ufe of cookery might be thus preferved throughout the year, as the pulp of boiled apples, goofeberries, &c. put into bottles, and placed fo as to be expofed to the wafted fteam of fteam-engines, or immerfed in the hot water, which flows from the condenfing of it; or near the boilers fixed behind fome kitchen fires; as I fufpect, that if fuch a degree of heat could be applied once a day, it would counteract the tendency to fermentation.

2. Another method of preferving fome fruits is by gathering them during their acid ftate, before that acid juice is converted into fugar, as lemons, oranges, goofeberries, pears, and fome apples; and if a part of the water be evaporated by a boiling heat fo as to leave the acidity more concentrated, it is lefs liable to ferment, and in confequence will be longer preferved. For this purpofe the fruit fhould be kept in a cellar, and corked in bottles, fo as to be precluded from the changes of air, and variations of heat; goofeberries, and rhubarb-ftalks, are thus fuccefsfully preferved for winter ufe; and if a tea fpoonful of brandy be put into each quart bottle, it will prevent the growth of mucor or mould upon them.

3. As fugar will not pafs into fermentation unlefs diluted with much water, and lefs fo in low degrees of heat, many fruits may be thus preferved by impregnating them with fugar, and the better if they are kept in a dry cellar. Dr. Hales found that by inverting the end of a branch of a tree into a bottle of brandy for a few hours, that the whole branch died; hence it is ufual and ufeful to cover preferved fruits with a paper moiftened with vinous fpirit, which prevents the growth of mucor or mould upon their furfaces, which is a vegetable thus eafily killed by the intoxicating ftimulus.

If fweet fruits be dried by heat, not only the fuperfluous water becomes exhaled, but the faccharine procefs is alfo promoted; and much of the mucilaginous or acid particles are converted into fugar, as in baking pears, or in drying figs, dates, raifins, apricots; fo that by by gradually drying them many fruits may be well preſerved, and require afterwards ſimply to be kept dry.

4. Some fruits, as the olive, are preſerved in their unripe ſtate in ſalt and water; the unripe pods of kidney-beans, and the hats of muſhrooms, may be thus alſo kept for months in weak brine in a cool cellar encloſed in bottles without much change. But the oily kernels of nuts are well preſerved in cellars beneath the ſoil to preclude the variations of heat, and covered in jars to prevent their evaporation. Other fruits are converted into pickles and preſerved in vinegar, but loſe their flavour; and others by being immerſed in vinous ſpirit are preſerved, as cherries, and thus tranſmuted from food to poiſon. And when the kernels of apricots, cherries, or bitter almonds, are preſerved in brandy, which is called ratafia, we poſſeſs a mixture of two of the moſt poiſonous productions of the vegetable kingdom; except perhaps the leaves of lauro-ceraſus diſtilled in alcohol, which was ſold as ratafia in Dublin, and produced many ſudden deaths in the gin-ſhops.

V. The following lines are inſerted to amuſe the reader, and to imprint ſome of the foregoing doctrine on his memory.

ART OF PRUNING WALL-TREES.

BEHEAD new-grafted trees in ſpring,
Ere the firſt cuckoo tries to ſing;
But leave four ſwelling buds to grow
With wide-diverging arms below;
Or fix one central trunk erect,
And on each ſide its boughs deflect.
In ſummer hours from fertile ſtems
Rub off the ſupernumerous gems;
But where unfruitful branches riſe
In proud luxuriance to the ſkies,

Exſect

Exſect the exuberant growths, or bind
A wiry ringlet round the rind;
Or ſeize with ſhreds the leafy birth,
And bend it parallel to earth.
When from their winter-lodge eſcape
The ſwelling fig, or cluſtering grape;
Pinch off the ſummit-ſhoots, that riſe,
Two joints above the fertile eyes;
But when with branches wide and tall
The vine ſhall crowd your trellis'd wall;
Or when from ſtrong external roots
Each rafter owns three vigorous ſhoots;
Watch, and as grows the aſcending wood,
Lop at two joints each lateral bud.
So ſhall each eye a cluſter bear
To charm the next ſucceeding year;
And, as the ſpiral tendrils cling,
Deck with feſtoons the brow of ſpring.
But when the wintry cold prevails,
Attend with chiſel, knife, and nails;
Of pears, plums, cherries, apples, figs,
Stretch at full length the tender twigs;
Vine, nectarine, apricot, and peach,
Cut off one third or half of each;
And, as each widening branch extends,
Leave a full ſpan between the ends.
Where crowded growths leſs ſpace allow,
Cloſe lop them from the parent bough;
But when they riſe too weak or few,
Prune out old wood, and train in new.
So, as each tree your wall receives,
Fair fruits ſhall bluſh amid the leaves.

ART OF PRUNING MELONS AND CUCUMBERS.

When melon, cucumber, and gourd,
Their two firſt rougher leaves afford,
Ere yet theſe ſecond leaves advance
Wide as your nail their green expanſe;
Arm'd with fine knife, or ſciſſars good,
Biſect or clip the central bud;
Whence many a lateral branch inſtead
Shall riſe like hydra's fabled head.
When the fair belles in gaudy rows
Salute their vegetable beaux;
And, as they loſe their virgin bloom,
Shew, ere it ſwells, the pregnant womb;
Lop, as each crowded branch extends,
The barren flowers, and leafy ends.
So with ſharp ſtings the bee-ſwarm drives
Their uſeleſs drones from autumn hives.
But if in frames your flowers confin'd
Feel not one breezy breath of wind,
Seek the tall males, and bend in air
Their diſtant lovers to the fair;
Or pluck with fingers nice, and ſhed
The genial pollen o'er their bed.
So ſhall each happier plant unfold
Prolific germs, and fruits of gold.

SECT.

SECT. XVI.

THE PRODUCTION OF SEEDS.

I. To produce feeds early. 1. *Sow before winter, or in warm fituations.* 2. *Tranfplant the roots.* 3. *Cut off fuperfluous fhoots.* 4. *Give lefs water.* II. To produce feeds in great quantity. 1. *Sow early, or when the feed ripens.* 2. *Tranfplant the roots deeper, or earth them up. Horfe-hoe and hand-hoe. Improved drill hufbandry. Dibbling. Corn lands laid level. Egyptian wheat with branching ears.* 3. *Deftroy the central fhoot. Eat down wheat and roll it. This is fometimes injurious.* 4. *Pinch off ufelefs fummits of beans. Eat down too vigourous wheat.* 5. *Roll it to leffen the ftraw.* 6. *Give lefs water.* III. To ripen feeds. 1. *Warmth and drynefs.* 2. *Frofty nights.* 3. *Lime forwards the ripening of feeds.* 4. *Cut off bulbs and root-fuckers of orchis. Helianthus tuberofus. Rheum palmatum.* IV. To generate beft kinds of feeds. *Choofe early plants infulated from others. Impregnate the ftigmas of fome with the anther-duft of others. Whence peas may be produced of different colours.* V. To collect good feeds. *Change of feeds is ufelefs, unlefs for better kinds. Choofe the earlieft feeds. Pick out the largeft potatoes for planting, and the beft radifhes for feed, and the earlieft ears of wheat.* VI. To determine the goodnefs of feeds. *Weigh a meafure of them. Caft them into falt water. Beans more economical than oats as provender. Seeds continue to improve during the water-months.* VII. To preferve feeds. 1. *Collect before they fhed naturally. Dry them before they are ftacked. Gluten of wheat deftroyed by fermentation. Make the corn-ftack higheft in the middle. The great durability of feeds. Keep them dry. Not in contact with walls. Convenient oat-boxes for ftables. Wheat dried on a malt-kiln to preferve it.* 2. *Ventilation prevents mould.* 3. *Seclude them from heat, beneath the foil. In ice-houfes.* 4. *Magazines of grain fuffered to vegetate at top. Covetous farmers.* 5. *New and old feeds.* 6. *Preferve feeds in fugar, or in charcoal, for long voyages. And flefh-meat in treacle.* VIII. To fow feeds advantageoufly. *Native*

Native feeds, foreign ones. Sow foon after the ground is turned over, and early in the fpring, in the autumn. 2. *Economy of fowing three kinds of grafs-feeds, and two kinds of wheat. Kinds of foil.* 3. *Mix fand or foil with fome feeds. Soak them in water, falt and water, lime. Steep barley in dunghill water. Wood-afhes. Sow wet as well as dry.* 4. *Bury the fruit with the feed.* 5. *Wafh the feeds of too luxuriant plants. Sow them early.* IX. Queftion concerning general enclofure. Cain and Abel.

Many of the circumftances above related concerning the production and enlargement of fruit are applicable to the production of the feeds, which are included in them; but thofe feeds, which contribute moft to the nourifhment of mankind, many of which are the progeny of annual or biennial plants, require other modes of cultivation.

As an introduction to this fection it may be obferved, how much more ingenuity was required in the difcovery of nourifhing mankind by the fmall feeds of the graffes, which have probably been fince much enlarged by perpetual cultivation, than by the large roots of potatoes. The Ifis or Ofiris of Egypt feems to have invented the procefs of cultivating wheat, as well as flax, on the banks of the Nile; and afterwards Ceres and Triptolemus to have taught the former of thefe important difcoveries all over the known world. While in later ages the Incas or Motezumas of Peru and Mexico feem to have deftroyed the cannibals, or men-eaters, of that continent, and to have difcovered and taught their people to fupport themfelves by the cultivation of potatoes.

I. 1. *To produce feeds early in the feafon.*

Thofe plants, which are required to yield a forward crop, as the peas and beans of our gardens, and thofe which our cold and fhort fummers will not otherwife perfectly ripen, as wheat, fhould be fowed before the commencement of winter, either in natural ground, as in the cultivation of wheat, or in ſituations ſheltered from the north-eaſt, as in the garden cultivation of peas and beans; or they may be ſowed very thick in hot-houſes, or under hot-bed frames, or under warm walls, and be tranſplanted, when they are one or two inches high, into the natural ground at due diſtances, when the weather is milder, and the plants are become hardier or leſs liable to be deſtroyed from their having longer acquired the habits of life.

When young plants of any kind are tranſplanted, the ground ſhould be recently dug, as their expeditious growth depends ſo much on the atmoſpheric air being buried in the pores or interſtices of the earth by the production of carbonic and nitrous acids, and ammonia, and heat.

The ſame advantage occurs by ſoaking ſeeds in water, or in the drainage from manure heaps, till they are ready to ſprout, and then ſowing them in a ſoil lately turned over; as their roots will then immediately put out by the newly generated heat, and newly produced carbonic acid in its fluid not its gaſſeous ſtate.

2. The tranſplanting of young roots, if they be ſet no deeper than before, does not, I ſuppoſe, multiply the number of ſtems, as occurs when wheat is tranſplanted ſo deep as to cover the ſecond joint; but by tearing off ſeveral ſmall extremities of the roots, the new production of many viviparous buds is prevented, and that of oviparous buds increaſed in conſequence, for reaſons mentioned in No. 2. 4. of the preceding Section.

When the roots of wheat are tranſplanted and divided, not only a great increaſe of the crop is produced, but I believe the ſeed is likewiſe ripened earlier, as is aſſerted by Mr. Bogle. Bath Society, Vol. III. p. 494. And it is well known to gardeners, that tranſplanting garden-beans forwards them in reſpect to time, but ſhortens the height of the ſtem. Hence tranſplanted vegetables grow leſs in height, as tranſplanted beans, and leſs branchy, as tranſplanted melons, but produce and ripen their ſeeds earlier; which is a great advantage in

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the ſhort ſummers of this climate; and if the roots can be divided, as in wheat, or new ſcions can be produced by their being tranſplanted deeper, as alſo occurs in wheat, the quantity of the ſeed may alſo be wonderfully increaſed by tranſplanting. See Sect. XII. 6.

3. Another mode of forwarding the production of ſeeds, and of ſooner ripening them, conſiſts in pruning off the viviparous tops or lateral ſhoots, which will bear no ſeeds at all, or only ſmall or imperfect ones, in our northern ſummers. For this purpoſe the cutting away the tops of beans and of peas, and the lateral branches of artichokes, after the fruit-buds are formed, both forwards and enlarges the flowers and ſeeds, which remain, as more nouriſhment is derived to them.

4. As a ſuperfluous ſupply of water is more friendly to the production of leaf-buds than to the generation of flower-buds, to derive leſs water than uſual to the roots, forwards the production of ſeeds, a fact well known in the gardens of warmer climates, which are perpetually watered from reſervoirs or wheel-engines. But when the bloſſoms appear, an addition of water muſt forward their growth by ſupplying nouriſhment, which ſhould again be leſſened when the fruit has acquired its full ſize, both to expedite its ripening, and to increaſe its flavour; as the ſaccharine matter and eſſential oil will be leſs diluted with water.

In the dry ſummer of 1799 I had the opportunity of flooding ſome rows of beans in my garden, which by being done too frequently, or too copiouſly, occaſioned them to grow to a much greater height than uſual, and in conſequence to bring to perfection few ſeeds, and ſome of them none. As I ſuppoſe the new ſhoots of fig-trees in the beginning of ſummer occaſions the firſt production of young figs to fall off from the want of that nouriſhment, which is now expended in the growth of new leaf-buds. See Sect. XV. 3. 4. Whence the facility of producing leaf-buds ſeems evidently to prevent the generation of flower-buds, and the ufe of cutting off the fummits of tall beans is thus explained, as directed above.

II. 1. *To produce feeds in great quantity* from annual or biennial plants they fhould be brought forward in refpect to the feafon in our northern fummers; that a greater quantity of viviparous buds may arrive early at their maturity for the purpofe of generating oviparous buds foon enough in the fummer to ripen their feeds; on this account thofe fhould be fown in the autumn which will bear the feverity of the winter.

Neverthelefs the feeds of thofe plants, which are natives of this climate, fhould probably be fowed at the time they become perfectly ripe, as occurs to them in their natural ftate; that is, either when the feed is fhed upon the ground by the parent plant, or when the fruit or hufk, which enclofes it, becomes naturally ripe after it has fallen on the ground. Thus I have feen crabs covered with leaves in hedge-bottoms, which have not decayed till the early fpring. Many pears do not become ripe in our ftore-rooms till March or April; and ivy berries and holly berries hang on their refpective trees till the vernal months, and are not till that time eaten by the thrufhes. Hence it is probable, that the feeds in thefe durable fruits or berries continue to ripen, or to become more mature, and prepared for their future growth during the winter months.

2. It was fhewn in Sect. IX. 3. 7. that when wheat was tranfplanted fo deep as to immerfe the firft joint above the root into the foil, many new ftems would fhoot up and ftrike their roots into the earth; and that thus four or fix new plants, or more, would be generated by the caudex of the leaf-bud, which conftitutes that joint. This mode of tranfplantation therefore will much increafe the quantity of the crop of feed, if it can be done foon enough for thefe additional ftems to ripen their corn, before the fummer ends.

There is another mode of increafing this product of additional

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ftems without tranfplantation, which confifts in fowing the wheat in rows by what is called a drill-plough according to Mr. Tull's method; and when the firft ftems rife a few inches high, a horfe-hoe, made like a very fmall plough, is to be brought fo near each row, as to turn up fome earth againft the ftems, fo as to cover the firft joint above the root with foil; whence new ftems will be generated, and fhoot up round the old one; and thus increafe the crop in the fame manner as by deep tranfplantation.

The theory of Mr. Tull's drill hufbandry is explained in Sect. IX. 3. 7. and in XII. 5. which is of late years fuppofed to have been improved by introducing the hand-hoe in place of the horfe-hoe, and thus giving an opportunity of fowing the rows or drills nearer together, as will be feen by the following method, now introduced into almoft general ufe in Norfolk by Mr. Coke; though Mr. Tull himfelf much prefers the horfe-hoe as turning over the earth much deeper than the hand-hoe, and thus rendering that part of it more expofed to the air, which was before more deeply fecluded from it; and alfo rendering it more pervious to vegetable roots; to which may be added, that both kinds of hoeing render the furface more permeable to the rains and dews, and prevent the cracks in dry weather, which are very injurious to the roots of plants; both which advantages depend on the porofity of the foil, which muft extend deeper by the ufe of the horfe-hoe than the hand-hoe.

Mr. Tull makes other ingenious remarks on the ufe of horfe-hoeing. In the beginning of winter, when the wheat has obtained one blade like grafs, or two or three leaves, the horfe-hoe is brought near the rows and deep, and the earth turned from them fo as to form a ridge between them. By this ridge in level grounds he thinks the rows are fhaded from the cold winds in fome fituations, and that the roots of the wheat are kept drier, and thence lefs injured by frofts. In the fpring this ridge in the intervals between the rows is divided by the horfe-hoe, and turned back againft the rows of corn after it

has

has been fertilized by the air and rains, and dews of winter. See Tull's Hufbandry, Ch. IX. and Sect. XII. 5. of this work.

Mr. Coke of Holkham in Norfolk affured me, that in thirteen years experience on a farm of 3000 acres he had found the drill hufbandry in that country greatly fuperior to fowing feeds of all forts by the hand in what is termed the broad-caft method, but differs in the number and arrangement of his rows from the method of Mr. Tull in the following circumftances.

Mr. Tull drilled two rows of feed a few inches from each other, and then left a fpace of two or three feet, and then drilled two more rows near each other, for the purpofe of paffing a hoe between each double row drawn by a horfe, which was therefore termed a horfe-hoe; but Mr. Coke drills all his rows of wheat and of peas nine inches from each other, and thofe of barley fix inches and three quarters from each other; this is performed by a drill plough made by the Rev. Mr. Cook, which drills fix rows at a time, and thus fows an acre of land in an hour, and is drawn by a fingle horfe; and the quantity of feed confumed is about fix or feven pecks to an acre, which is about half what is ufed in the fowing by the hand in the broad-caft method.

Early in March Mr. Coke ufes the hand-hoe, which for hoeing the rows of wheat and of peas is about fix inches wide, and for hoeing thofe of barley about four inches wide. By this hoe the furface is not only turned over, and the weeds between the rows rooted up, but it is alfo accumulated about the roots of the growing corn, and covers and confequently deftroys the low growth of poppies amongft them; which are a very frequent weed in that part of the country. A fecond hoeing is performed about the middle of May, and the foil is again not only cleared from weeds but accumulated againft the rifing corn, each of which hoeings coft about twenty-pence an acre.

Neverthelefs I am informed, that fome attentive agricultors ufe the horfe-hoe belonging to Mr. Cook's drill-machine, though the rows of corn are but nine inches from each other; and aſſert, that this occaſional trampling of the horſe on the young plants is of no very ill conſequence, a circumſtance well worth obſerving, as it removes the principal diſadvantage of the horſe-hoe, which conſiſts in the too great diſtance of the alternate rows of the corn-plants.

By the earth being thus accumulated againſt the roots of the corn it is ſaid to tiller or tellure much; that is, to throw out four or ſix ſtems, or more, around the original ſtem, and thus to increaſe the number of ears like tranſplanting the roots, inſomuch that Mr. Coke obtains by this method between four and five quarters of wheat on every acre, which in the broad-caſt method of ſowing did not yield more than three quarters on an acre, beſide ſaving a ſtrike and half of the ſeed corn, unneceſſarily conſumed in the broad-caſt method of ſowing. To this ſhould be added another advantage, that as the land is thus kept clear from weeds, and has its ſurface twice turned over, and thus expoſed to the air, it is found to ſave one ploughing for the purpoſe of a ſucceeding crop of turnips.

It is probable, that one hand-hoeing in the beginning of winter, ſo managed as to turn the ſoil from the roots of the corn, and to leave it rather elevated between the rows, as Mr. Tull recommends to be performed by his horſe-hoe, might give a ſimilar advantage to this mode of cultivation; and alſo if another hand-hoeing was applied, as ſoon as the wheat is out of bloſſom, to ſupply more nouriſhment to the young ſeed might increaſe its plumpneſs and weight, as mentioned in No. 2. 3. of this Section.

The lands thus managed by Mr. Coke are laid level, and not in ridges and furrows, and can thus be ploughed croſswiſe; and the crop is equally good throughout the whole; whereas in the furrows of ſome lands it is leſs forward or leſs prolific than on the ridges; whence much light corn is mixed with the good, which is obliged to be ſeparated from that, which is marketable, and uſed for hogs or poultry. Add to this, that in this mode of huſbandry the ſtraw is be-

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lieved to be larger and in greater quantity as well as the grain, and the land to be lefs impoverifhed, as no weeds are fuffered to grow on it, and as its furface is fo frequently turned over, and expofed to the air.

In China the corn lands are laid on a level, not in ridges and furrows; which is fuppofed to be the moft advantageous plan in almoft every fituation, which is proper for the cultivation of corn, as by being thus rendered capable of being divided by crofs-ploughing, almoft any kind of foil may be rendered more proper for the ufe of the drill hufbandry, by which it is feen in the above account of the Norfolk management, that twelve ftrikes more of wheat are raifed on an acre, and one ftrike and a half faved in the confumption of feed-wheat, which at fix fhillings a ftrike arifes to a confiderable fum on a large farm.

Neverthelefs there feem to be many advantages attending the forming the furface of land into ridges and furrows; in wet lands with a fubftratum of clay the furrows are convenient channels to carry off the water, where there is a fufficient declivity, as treated of by Mr. Tull in his Horfe-hoeing Hufbandry, Ch. XVI. Add to this, that in fome fituations a deeper ftratum of the foil, where it is valuable, may be occafionally turned up, and expofed to the air, and to the roots of vegetables, by gradually changing the locality of the ridges; and laftly, in every fituation a greater furface both of the foil, and of the fummits of the ftems, or ears, are expofed to the influence of the air by means of ridges and furrows; for as the plants of wheat are but three or four feet high, the furface of a crop of wheat is increafed as well as the furface of the ground it grows upon, and not as the bafe on which the declivities or hills reft, as fome have erroneoufly fuppofed. See Sect. X. 3. 8.

There is another method of fowing wheat in rows ufed in fome counties, which is termed dibbling in the language of agricultors, and confifts in making perpendicular holes one inch and half or two inches

inches deep, as is commonly done in planting potato-roots; thefe holes are made by a man, who has a proper ftaff fhod with iron in each hand, and as he walks backwards is able by looking at the part of the row already made to keep nearly in a ftraight line, and to make two holes at once at about nine inches diftant from each other every way. Two or more children attend the man, and drop two, or three, or four feeds into each perpendicular hole, which are afterwards covered by drawing over them what is called a bufh-harrow.

This method by fowing the wheat in rows adapts it for the ufe of the hand-hoe, as by fowing it by a drill machine, but muft be attended with greater expence, and I fufpect with lefs accuracy of the diftribution of the feed, owing to the hurry or fatigue of the children employed; and I alfo fufpect that fowing in drills is preferable, becaufe a greater quantity of earth is turned over, and much air in confequence included in its interftices; whereas in making perpendicular holes the fides of the holes are compreffed, and rendered more folid; whence potato-roots alfo might probably be more advantageoufly planted by making drills inftead of perpendicular holes.

A correfpondent of the board of agriculture afferts, that on looking over a field of potatoes near Leicefter, which had all been planted at the fame time, and on land equally manured, he obferved a great difference of the growth of one part of the field, which on inquiry he found to have been owing to the roots having been planted in drills, where the plants were fo much ftronger; and by a fetting ftick in holes, where they were fo muchlefs vigorous; Englifh Enclyclopedia, Art. Hufbandry, p. 483: which difference of growth I fuppofe to have been owing to the circumftances above mentioned.

A few ears of wheat were lately given me, which were branched, having four or five lefs ears growing out of each fide of the principal ear; it was procured at Liverpool, and was called Egyptian wheat, or Smyrna wheat. It is defcribed in the Supplem. Plantarum of the

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younger Linneus, as well as in the ſpecies Plantarum of the elder; and is ſaid to be a native of Egypt, and to be cultivated at Naples; it is called "triticum compoſitum, or wheat with a compound ear, crowded with leſs ears, awned; and is ſaid to be related to triticum æſtivum, ſummer wheat; but the ſpike is four times larger, a hand in length, compoſed of leſs ſpikes, two faced, alternate, approximated, from nine to twelve, the lower ones being ſhorter, and the top one ſolitary." Suppl. Plant. p. 115.

The plant, which was given me, had five tall and thick ſtems from one root, but ſeemed to have been plucked up before it was quite ripe, whence I cannot judge of the ſize of the grain, but ſhould imagine, that it is a ſpecies well worthy of attention. The few ears, which I poſſeſſed, were ſown in the ſpring of this year, 1799, not having obtained them ſoon enough to ſow in the autumn. When they were an inch or two high, they were tranſplanted into a moiſtiſh part of my garden; and though the year has been uncommonly cold and wet, and a great part of the autumn-ſown wheat of this country is blown down upon the ground, and is not yet ripe, yet almoſt every root of the Egyptian wheat has from ten to twelve ſtems, and ſtands upright on ſtrong ſtraw about three and a half, or four feet high. The beſt ſtems have one principal ear about five inches long, with five or ſix ſhorter ones branching out on each ſide of it. They begin to appear brown, and I hope will ripen. I have ſince found that this ſpecies of wheat is mentioned in Tull's Huſbandry under the name of Smyrna wheat. He adds that it is highly productive, but on that account requires a good ſoil.

3. Another method of promoting the growth of lateral ſtems conſiſts in deſtroying the central ſhoot; when this is done, other new ſtems ariſe from the joint immediately above the root, which in wheat is in contact with the earth. On this account, when wheat plants are ſufficiently forward in reſpect to the ſeaſon, it is thought to be advantageous to eat the firſt ſtem down by ſheep to increaſe the

quantity

quantity of the ſubſequent crop. See Sect. IX. 3. 7. It ſhould be nevertheleſs obſerved here, that the trampling of the ſheep on lands, which are not too adheſive, will preſs down the firſt or ſecond joint into the earth, and thus aſſiſt the production of many ſide ſhoots. But in very adheſive ſoils this trampling of the ſtems into the ground may be injurious. See a paper in Bath Agriculture, Vol. I. Art. XV. In ſoils which are not too adheſive, when the crop appears thin, it is probable, that a roller drawn over it by preſſing the firſt or ſecond joint into the ſoil, might promote the production of ſide ſhoots, or make them tiller, or tellure, in the language of agricultors. And when graſs or clover ſeeds are deſigned to be ſown on the wheat-land, it might firſt be harrowed, and then either rolled or trampled by the ſheep, which eat it; either or both of which might preſs down the root-ſtems of the corn, and cover the newly ſown clover-ſeeds with ſoil.

This mode of eating down forward wheat with ſheep is analogous to cutting off the central buds of melons and cucumbers to make them produce earlier fruit, and in this climate perhaps in greater quantity; as thoſe produced after the great extent and elongation of the central branches would be too late to ripen in this climate: and by their exuberant generation of a viviparous progeny would retard the ſucceſſion of lateral ſhoots, and a conſequent quicker production of flowers.

Nevertheleſs where the crop is not too luxuriant or too forward, the eating down the firſt ſtem by ſheep may be an injurious practice; as Mr. Tull thinks, that by thus deſtroying the firſt ſtem, the ears of the later ones have not time to ripen, and thence become light in reſpect to the ſize or plumpneſs of the grain; and that theſe ſecondary ſtems become weak, and are liable to fall down, both which he ſays commonly occur where the crops are eaten by ſheep.

Mr. Tull, whoſe work is throughout a great effort of human genius, adds a very wiſe axiom, " that it is moſt advantageous to haſten,

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what we can, the time of bloſſoming; and to protract the time of ripening." Horſe-hoeing Huſbandry, Ch. XI. p. 147; for it is the farinaceous reſervoir of nutriment laid up in the cotyledon of the new ſeed for the future growth of the corculum or new embryon, for which we cultivate the plant; and this reſervoir is formed between the bloſſoming and ripening of the grain, either before or after the impregnation of the pericarp, or ſeed-veſſels, and thus renders the grain plump and heavy. Mr. Tull in another part of his work recommends an additional horſe-hoeing immediately after the bloſſom is over, to ſupply more nutriment to the ripening grain. Ch. IX. p. 120. Mr. Tull eſteems the eating down of wheat by ſheep to be generally a very injurious practice in this climate, by rendering the ears light and the ſtraw weak; by retarding the time of bloſſoming, as well as the growth of the ſtems.

4. In the moiſt ſprings of this climate many annual or biennial plants are liable to ſhoot out too many or too ſtrong viviparous branches, which can not generate flower-buds ſoon enough to ripen their ſeeds in our cold and ſhort ſummers. This always happens to cucumbers and melons, which were brought from warmer countries, and to the peas and beans of our gardens, and ſometimes to corn-plants, which are liable in wet ſeaſons to produce too ſtrong ſtems and foliage, which have not time to generate the flower-bud at their ſummit ſoon enough to perfect and to ripen the ſeed. Melons and cucumbers have been mentioned in Sect. XV. 2. 5. and in reſpect to garden beans their viviparous tops ſhould be pinched off, which if not too old may be eaten as an agreeable vegetable, when well boiled; and thus more nutriment is derived to the oviparous buds beneath, which renders them larger, and perhaps more numerous. To prevent field peas from running into ſtraw in moiſt ſoils leſs manure ſhould be uſed; and field beans may have their tops cut off by a ſcythe fixed into a ſtraight ſhaft.

Annual cotton plants are much cultivated in ſome colder parts of the

the Chineſe empire, and the cultivators lop off the tops to increaſe the number of pods, and to haſten their production; and in the Weſt Indies the flowers of the roſe tree are believed to be accelerated and increaſed by topping the branches. Embaſſy to China by ſir G. Staunton, Vol. III. p. 202. 8vo. edit.

When the ſtems and foliage of wheat are thus too vigorous, it may be advantageous to eat it down by ſheep as above mentioned; which may not only deſtroy the too vigorous viviparous central ſtems, but alſo produce a greater number of lateral ones; which may ſooner terminate in oviparous ones, ſo as to produce more grain with leſs ſtraw.

5. It is alſo probable, that rolling them as mentioned above, if it be done in a morning before the dew is off, might ſo far bruiſe the ſtems and roots, as to ſtop their too great propenſity to nouriſh the viviparous buds, and in conſequence to favour the growth of the oviparous buds on their ſummits; which might forward the harveſt ſeaſon, as well as increaſe the product of grain in proportion to the quantity of ſtraw. From rolling wheat in ſpring on fields where the ſurface remains uneven or cloddy, another advantage may be derived, by breaking the clods or eminences, and thus earthing up many of the ſtems above the ſecond joint, and thus inducing a new ſet of rootſcions to put forth, or tiller. See Sect. XII. 3.

6. The garden plants, which are too vigorous, in ſituations where there is a command of water, as in the gardens of warm climates, ſhould have leſs water derived to them, till the bloſſoms appear; becauſe a greater quantity of moiſture facilitates the production of viviparous buds ſo much as to retard that of oviparous ones, and thus diminiſhes the quantity as well as retards the ripening of the crop. But in theſe ſituations, as ſoon as the bloſſoms appear, a greater ſupply of water ſhould be allowed, which will contribute to nouriſh and enlarge them, as mentioned above; as is practiſed in ſome countries of the eaſt, where they do not flood their rice-grounds, till they are in flower.

flower. See Sect. XV. 3. 4. But lefs water is again required, when the feed has arrived at its full fize, as before fpoken of.

III. 1. *To forward the ripening of feeds.* A due degree of warmth and of drynefs feems to include the circumftances principally required. The warmth not only accelerates the various fecretions of vegetables by increafing their irritability and confequent activity, but, after the mucilaginous, ftarchy, faccharine, and oily matters are fecreted into proper refervoirs, may contribute perhaps chemically to their change into each other, or to their greater perfection. And the drynefs of the air, whether hot or cold, is neceffary to give perfect ripenefs to feeds; as otherwife the due exhalation of the aqueous parts of the fecreted fluids, which form the nutritive parts of feeds, does not properly proceed; and the feed gathered in this condition is liable to mildew in the barn or granary, or to become fhrivelled and wrinkled, as it dries.

2. It is believed in Scotland, that even the frofty nights of autumn contribute to ripen the late crops in that inclement climate, which fome have afcribed to the moonlight, but, which I have indeed fufpected, that the froft may in fome meafure effect by converting the mucilage of the grain fooner into ftarch. This I was induced to imagine by having obferved that bookbinder's pafte, made by boiling wheat-flour in water, loft its adhefion after having been frozen; and alfo from a culinary obfervation, that when ice or fnow is mingled with flour inftead of water in making pancakes, that it much improves them; the truth of which I have heard boldly afferted, but never witneffed the experiment. See Sect. VI. 3. 3.

There is neverthelefs an experiment related by Dr. Roebuck in the Edinburgh Tranfactions, Vol. I. which feems to fhew, that the grains of oats continue to fill and to become heavier even during the autumnal frofts; which may probably occur during the funfhine of the middle part of the day, as occurs in the vernal frofts of this part of the country. In 1780 near Borrowftonefs the oats were green even

even in October, when the ice was three fourths of an inch thick. He felected feveral ftalks of oats of nearly equal fulnefs, cut half of them, and marked the remainder, which continued fourteen days longer in the field; after being dry, the grains of each parcel were weighed; and eleven of thofe grains, which had remained in the field, weighed thirty of thofe which had been cut a fortnight fooner.

This important experiment fhould teach our farmers not to cut their peas and beans too early in inclement autumns; which are fo frequently feen to become fhrunk and fhrivelled in the barn or granary, and inclined to rot from deficient ripenefs, and confequent foftnefs or moifture; and thus contain much lefs flour in proportion to the hufk or bran.

3. The wheat produced after land has been much limed, is believed to be thinner fkinned, and to yield more good meal, than other wheat, and to make better bread. See Sect. X. 6. 7. On this account I fuppofe one ufe of lime is to forward the ripening of feeds by converting their mucilage fooner into ftarch or oil; as according to the experiments of M. Parmentier the goodnefs of bread depends much on the quantity of ftarch contained in it; who found, that if the ftarch taken from eight pounds of raw potatoes, by grating them into cold water, was mixed with eight pounds of boiled potatoes, as good bread might be produced as from wheat flour. See Sect. VI. 3.

4. The feeds of fome plants, which alfo propagate themfelves by bulbs at their roots, will not ripen in this climate naturally, as the orchis; but are faid to ripen, if the new bulb be cut off early in the feafon; or if the propagation by their roots be retarded or prevented by confining them in garden-pots, as the lily of the valley; and it is probable, that the feeds of potatoes might be rendered more perfectly ripe, and in confequence better for the cultivation of new varieties; if the young roots were taken away early in the feafon from that, which is to bear feed; or if they were confined in garden pots.

If the orchis could by theſe means be cultivated from ſeed on moiſt meadows or moraſſes, it might become a profitable article of huſbandry; as when it is ſcalded in boiling water, and the peel rubbed off, it is ſold by the name of ſalep, and might become a nutritive article of diet, like ſago and vermicelli, if it could be propagated at leſs expence.

It is alſo probable, that Jeruſalem, or ground artichokes, helianthus tuberoſus, might be induced to ripen its ſeeds in this country, if the new roots from a few of the forwardeſt plants were taken away early in the ſeaſon, or if they were confined in garden pots. And if this plant could be propagated by ſeed, it might make an uſeful product in agriculture, as horſes are very fond of the leaves, and ſwine of the roots; both of which are produced in great quantity; and as the latter contain much ſugar, they muſt be very nutritive; and in reſpect to their culinary uſe are remarkably grateful to moiſt palates, as well as nutritive, when cut into ſlices, and baked in beef or mutton pies; but are ſaid to be flatulent in the bowels of thoſe whoſe digeſtion is not very powerful; a property which might be worthy attention, where the propenſity to fermentation is required, as in making bread with potatoes, or in the diſtillery.

It is alſo probable, that if the large new root-ſuckers of other perennial plants, which do not bear bulbous or tuberous roots, and which are late in ripening their ſeeds, or do not ripen them perfectly in this climate, were cut or torn off early in the ſeaſon, as of the rheum palmatum, palmated rhubarb, or rheum hybridum, mule rhubarb; or if their roots were confined in garden-pots, that they might be more liable completely to ripen their reſpective ſeeds. See Sect. XV. 2. 4.

IV. 1. *To generate the beſt kinds of ſeeds* the moſt healthy plants muſt be choſen, and thoſe which are moſt early in reſpect to the ſeaſon; theſe ſhould be ſo inſulated, as to have no weak plants of the ſame ſpecies, or even genus, in their vicinity, leſt the fecundating duſt of weaker plants ſhould be blown by the winds upon the ſtigmata of the ſtronger, and thus produce a leſs vigorous progeny.

Where new varieties are required, the male duſt of one good variety, as of the nonpareil apple, ſhould be ſhed upon the ſtigmas of another good variety, as of the golden-pippin; and it is probable ſome new excellent variety might be thus generated.

Mr. Knight has given a curious experiment of his impregnating the ſtigmas of the pea-bloſſoms of one variety with the farina of another. He ſays, Treatiſe of Apple and Pear, p. 42, "Bloſſoms of a ſmall white garden-pea, in which the males had previouſly been deſtroyed, were impregnated with the farina of a large clay-coloured kind with purple bloſſoms. The produce of the ſeeds thus obtained were of a dark grey colour, but theſe having no fixed habits, were ſoon changed by cultivation into a numerous variety of very large and extremely luxuriant white ones; which were not only much larger and more productive than the original white ones, but the number of ſeeds in each pod was increaſed from ſeven or eight to eight or nine, and not unfrequently to ten. The newly made grey kinds I found were eaſily made white again by impregnating their bloſſoms with the farina of another white kind. In this experiment the ſeeds, which grew towards the point of the pod, and were by poſition firſt expoſed to the action of the male, would ſometimes produce ſeeds like it in colour, whilſt thoſe at the other end would follow the female.

"In other inſtances the whole produce of the pod would take the colour of one or other of the parents; and I had once an inſtance in which two peas at one end of a pod produced white ſeeds like the male, two at the other end grey ones like the female, and the central ſeeds took the intermediate ſhade, a clay colour. Something very ſimilar appears to take place in animals, which produce many young ones at a birth, when the male and female are of oppoſite colours. From ſome very imperfect experiments I have made, I am led to ſuſpect that confiderable advantages would be found to arife from the ufe of new or regenerated varieties of wheat, and thefe are eafily obtained, as this plant readily fports in varieties, whenever different kinds are fown together." See Sect. VII. 2. 6. of this work.

2. The white and blue peas fown in fields as well as in gardens fometimes poffefs the property of becoming foft by boiling, at other times not. This circumftance is faid to depend on the nature of the foil, but has not yet been fufficiently inveftigated; perhaps the greater or lefs maturity of the peas at the time of reaping them may have more or lefs contributed to fill their fibrous cells or divifions with mucilage or ftarch. The greater or lefs mealinefs produced by boiling potatoes feems to be an analogous circumftance, and is thought by fome to arife from the nature of the foil rather than from the fpecies or variety of the planted root.

The mealinefs of fome boiled potatoes, and the foftnefs of fome boiled peas, may occafionally be affected by the acidity of the fpring water, in which they are boiled; but is generally I fuppofe owing to the mucilage of fome of them being more or lefs coagulable by heat, than that of others. Something fimilar to which obtains in animal mucus, as the cryftalline humour of the eyes of fifh become hard and opake by boiling; while the fkins of animals, and the tendons of their feet, become a foft mucus or jelly by boiling; and fome of the liquids, which are found in the cells or cavities of the body in dropfies, are obferved to coagulate by heat, and others to become more fluid. The caufes of this difference merits further inquiry.

V. 1. *To collect good feeds*, according to the obfervations of Mr. Cooper of Philadelphia, confifts not in procuring new feeds from diftant places, as is generally fuppofed, but in felecting the beft feeds and roots of his own; which though he has continually fown or planted them in the fame foil, every article of his produce is greatly fuperior to thofe of any other perfon, who fupplies the market, and they feem ftill in a ftate of improvement. He believed that no kind of inceft

would

would degenerate the breeds of vegetables, and therefore adopted the plan of Mr. Bakewell in England in refpect to quadrupeds, who continued to improve his flocks and herds by the marriages of thofe, in which the properties he wifhed to produce were moft confpicuous without regard to confanguinity or inceft.

Mr. Cooper was led to his prefent practice, which he began more than forty years ago, by obferving that vegetables of all kinds were very fubject to change with refpect to their time of coming to maturity, and other properties, but that the beft feeds never failed to produce the beft plants. Among a great number of experiments he particularly mentions the following.

"About the year 1746 his father procured feeds of the long watery fquafh, and though they have been ufed on the farm ever fince that time without any change, they are at this time better than they were at the firft.

"His early peas were procured from London in the year 1756, and though they have been planted on the fame place every feafon, they have been fo far from degenerating, that they are preferable to what they were then. The feeds of his afparagus he had from New York in 1752, and though they have been planted in the fame manner, the plants are greatly improved.

"It is more particularly complained of, that potatoes degenerate, when they are planted from the fame roots in the fame place. At this Mr. Cooper fays, he does not wonder, when it is cuftomary with farmers to fell or confume the beft, and to plant from the refufe; whereas having obferved that fome of his plants produced potatoes, that were larger, better fhaped, and in greater abundance than others, he took his roots from them only; and the next feafon he found, that the produce was of a quality fuperior to any, that he had ever had before. This practice he ftill continues, and finds that he is abundantly rewarded for his trouble.

"Mr. Cooper is alfo careful to fow the plants, from which he raifes his ſeed, at a conſiderable diſtance from any others. Thus, when his radiſhes are fit for uſe, he takes ten or twelve, that he moſt approves, and plants them at leaſt one hundred yards from others, that bloſſom at the ſame time. In the ſame manner he treats all his other plants, varying the circumſtances according to their nature.

"About the year 1772 a friend of his ſent him a few grains of a ſmall kind of Indian corn, not larger than gooſe ſhot, which produced from eight to ten ears on a ſtalk. They were alſo ſmall, and he found, that few of them ripened before the froſt. Some of the largeſt and earlieſt he ſaved, and planted them between rows of a larger and earlier kind, and the produce was much improved. He then planted from thoſe that had produced the greateſt number of the largeſt ears, and that were the firſt ripe, and the next ſeaſon the produce with reſpect to quality and quantity was preferable to any, that he had ever planted before.

"The common method of ſaving ſeed-corn by taking the ears from the heap is attended, he ſays, with two diſadvantages; one is the taking the largeſt ears, of which in general only one grows on a ſtalk, which leſſens the produce; and the other is taking ears that ripen at different times.

"Many years ago Mr. Cooper renewed all the ſeed of his winter grain from a ſingle plant, which he had obſerved to be more productive, and of a better quality than the reſt; which he is ſatisfied has been of great uſe. And he is of opinion, that all kinds of garden vegetables may be improved by the methods deſcribed above, particular care being taken that different kinds of the ſame vegetables do not bloom at the ſame time near together; ſince by this means they injure one another." Communications to the Board of Agriculture, Vol. I. part 3. Letter from Dr. Prieſtley.

2. As the varieties of plants are believed to be produced by different ſoils and climates, which varieties will afterwards continue through many generations, even when the plants are removed to other ſoils

and

and climates, it muſt be advantageous for the agricultor to inſpect other crops as well as his own; and thus wherever he can find a ſuperior vegetation to collect ſeeds from it; which is more certain to improve his crops than an indiſcriminate change of ſeed.

But where ſeed-corn is purchaſed without a previous obſervation of its ſuperior excellence, perhaps it would be more advantageous to take that from better kinds of ſoil, and from ſomewhat better climates; as the good habits acquired by ſuch ſeeds may be continued long after their removal to inferior ſituations. And on the contrary, care ſhould be taken not to collect a change of ſeeds from worſe climates or inferior ſoils, unleſs the agricultor is previouſly certain that they are of a ſuperior kind.

VI. 1. *To determine the goodneſs of ſeeds*, the weighing a given meaſure of them may generally be eſteemed a criterion; as it is known, that when ſeeds are put into cold water, thoſe which are leſs perfect are liable to ſwim, and the ſound ones to ſink; thus the imperfect ſeeds of rye-graſs and of clover may be detected by throwing a ſpoonful of them into water; but the ſeeds of rye-graſs are ſaid to be frequently adulterated by a mixture of the ſeeds of twitch or dog's graſs, which can only be diſcovered by an experienced eye. This even is ſaid to be a teſt of the goodneſs of malt; as thoſe grains, which are not perfectly germinated, will ſwim with one end upwards, I ſuppoſe the root end; and thoſe which are perfectly germinated ſwim on their ſide, whilſt the ſound ungerminated barley ſinks in water.

It is therefore a proper criterion of good ſeed-wheat to caſt it into ſalt and water, juſt ſo ſaline as to float an egg; as the more ſalt is diſſolved in the water, the heavier it becomes; and hence none but quite ſound grains of wheat will ſink in this brine; and that which ſwims is properly rejected. This rejection of the light grains by ſteeping wheat in brine is probably of greater conſequence to the enſuing crop, than the adheſion of any ſalt to the grain, which has been believed to deſtroy the eggs of inſects ſuppoſed to adhere to it, or to fertilize the ſoil.

2. The weight of a given meaſure of corn will alſo with conſiderable certainty diſcover the quantity of huſk or bran contained in it, compared to the quantity of flour; as that grain, which is cut too early, or which is otherwiſe not quite ripe, as happens in wet ſeaſons, ſhrinks in the barn or granary, and becomes wrinkled, and has thus a greater proportion of ſkin or bran, than that which has been more perfectly ripened, and will hence weigh lighter in proportion.

A teſt of this kind may enable us to determine whether peas and beans, or oats, are preferable in reſpect to economy as provender for horſes. A ſtrike or buſhel of oats weighs perhaps forty pounds, and a ſtrike or buſhel of peas and beans perhaps ſixty pounds; and as the ſkin of peas and beans is much leſs in quantity than that of oats, I ſuppoſe there may be at leaſt fifteen pounds of flour more in a ſtrike of peas and beans than in a ſtrike of oats. There is alſo reaſon to believe, that the flour of beans is more nutritive than that of oats, as appears in the fattening of hogs; whence according to the reſpective prices of theſe two articles I ſuſpect, that peas and beans generally ſupply a cheaper provender for horſes than oats, as well as for other domeſtic animals.

But as the flour of peas and beans is more oily, I believe, than that of oats, it may in general be ſomewhat more difficult of digeſtion; hence when a horſe has taken a ſtomach full of peas and beans alone, he may be leſs active for an hour or two, as his ſtrength will be more employed in the digeſtion of them, than when he has taken a ſtomach full of oats. According to the experiment of a German phyſician, who gave to two dogs, which had been kept a day faſting, a large quantity of fleſh food; and then taking one of them into the fields hunted him with great activity for three or four hours, and left the other by the fire. An emetic was then given to each of them, and the food of the ſleeping dog was found perfectly digeſted, whilſt that of the hunted one had undergone but little alteration.

Hence it may be found adviſable to mix bran of wheat with the peas and beans, a food of leſs nutriment, but of eaſier digeſtion; or to let the horſes eat before or after them the coarſe tuſſocks of ſour graſs, which remain in moiſt paſtures in the winter; or laſtly, to mix finely cut ſtraw with them.

3. Another way of diſtinguiſhing light corn from heavy is by winnowing; as the ſurface of the light grains being greater in proportion to their ſolid contents, they will be carried further by the current of air, which is produced by the van; though the heavy grains would roll further on the floor after rolling down a grate to ſeparate the duſt; becauſe their vis inertiæ would carry them further, after they are put in motion; and their ſurfaces would be reſiſted by the air no more than thoſe of the lighter grains.

4. Finally, there is reaſon to believe that a progreſſive improvement of many ſeeds exiſts during the warmer days of winter in our granaries, which probably conſiſts in the proceſs of the converſion of mucilage into ſtarch; in the ſame manner as the harſh juices of crab-apples, and of auſtere pears, are continually changing into ſugar during the winter; both which proceſſes are probably in part chemical, like the ſlow but perpetual change of ſugar into vinous ſpirit, when the juices of ſweeter apples and pears, or grapes, are put into bottles in the manufacture of cyder, perry, and wine.

This improvement of wheat, and of barley, and of oats, is well known to the baker, the maltſter, and the horſe-dealer; as better bread is made from old wheat, and barley is converted into better malt in the vernal months; and horſes are believed to thrive better, and to poſſeſs more vigour, when they are fed with old than with new oats.

VII. 1. *The preſervation of ſeeds* next demands our attention. Thoſe ſeeds which are liable to lie upon the ground, as peas and

corn,

corn, when thrown down by ftormy or wet feafons, fhould be gathered rather earlier; left they fhould begin to germinate, as they lie upon the ground, and would hence become a kind of malt after drying. Other feeds fhould be gathered, before they would fpontaneoufly fall from their pericarps, to prevent the lofs which muft otherwife enfue in the reaping, or mowing, and carrying them to the barn, which often amounts to as much as is neceffary to fow the land, which produced it, as well as to fupply the depredations of birds, infects, and vermin.

Monf. B. G. Sage accufes the farmers of fome parts of France of collecting their wheat with many green weeds immediately after reaping it, and preffing it clofe together in their barns; by which the ftack undergoes a fermentation with great heat like fome hayftacks; and that the corn is by this fermentation killed, and will not grow when fown like hay-feeds from a fermented hay-ftack, mentioned in Sect. X. 11. 7; and alfo that the gluten, or vegeto-animal matter of the corn, is deftroyed; and it on that account makes lefs agreeable and lefs wholefome bread; and laftly, that the ftraw is much injured by becoming mouldy. Journal de Phyfique, Sep. 1794.

Monf. B. G. Sage adds, that the following procefs will difcover, whether wheat has been thus injured, which may be interefting both to the baker, and wheat-buyer, who wants it for feed-wheat. Make a pafte with flour and water, then wafh it with your hands under water, which muft be frequently changed, till it no longer becomes difcoloured. The fubftance remaining in the hands is the gluten; if the corn be good, this is elaftic, and will contract when drawn out; if the corn has begun to heat, it is brittle; if the corn has fermented, none of the gluten will be obtained.

In this country, where corn is feldom cut too early, or preffed together on the ftack, the principal circumftance required is to keep it dry; as the ftraw is not liable to ferment like new hay made with young grafs, which contains fugar at every joint of the ftem. To preferve

preferve a ftack of wheat dry, a good cover of thatch may feem fufficient; but as this is liable to injury by vermin, it would be an additional fecurity, if at the time of making the ftack the fheaves were laid higheft in the middle, and lower on every fide, fo that if any wet fhould find its way into the ftack, it might drain onwards along the ftraw of the fheaves, which would thus act like thatch throughout the whole ftack.

There are inftances of great durability of feeds, which have been preferved dry, and fecured from either fo great heat or fo great cold, as might deftroy their life or organifm. Thus there is an account of the feeds of Indian wheat, which grew well in a hot-houfe after having been kept thirty-four years, as was accurately afcertained. Bath Society, Vol. V. p. 464. And it has been lately afferted, that many feeds of more than a hundred years old, which were found in fome old herbarium at Vienna, have been made to germinate by the ufe of oxygenated muriatic acid and water. Philof. Magaz. But if the organic life of a feed be deftroyed by froft, or fire, or mechanic injury, putrefaction fucceeds, and decompofition; as when the organic life of an egg is deftroyed by violently agitating it, it is known foon to putrefy.

To preferve feeds in barns or granaries our principal attention fhould be firft to make them dry, and fecondly to keep them dry; becaufe no feeds can vegetate without moifture. The art of drying moft feeds muft confift in duly ventilating them, efpecially on dry days; which may be done by frequently turning over the heaps of them; and to preferve them dry in this climate the door and windows of granaries fhould open to the fouth to receive the warmth of the fun, with apertures round the building for fufficient ventilation; which muft be prevented from admitting rain or fnow by fheltering boards on the outfide.

The heaps of corn fhould be furrounded with boards to keep them from contact with brick or ftone walls; which, when warm moift

 fouth-

fouth-weft winds fucceed cold north-eaft winds, are liable to precipitate the moifture from the atmofphere by their coldnefs, and to communicate it to all bodies in contact with them. For a fimilar purpofe in ftables fome have put up a tall wooden trunk from the chamber to the room below, three or four feet fquare, and ten or twelve feet high, with a fliding valve to draw out the corn below, which is poured in at the top; in three or four places a tin or wooden pipe full of holes is made to pafs horizontally through the box to give air to the corn, the whole of which, when any of it is drawn out below, is moved in defcending; and new furfaces of corn are applied to the air-holes of the horizontal tubes.

The moft fecure way of preferving a great quantity of wheat, according to Mr. Tull, is by gently drying it on a hair-cloth in a malt-kiln, with no other fuel but clean ftraw, and no greater heat than that of the funfhine. In this fituation the wheat remained from four hours to twelve hours, according to the previous dampnefs of it. Mr. Tull knew a farmer in Oxfordfhire who purchafed wheat, when it was cheap, and kept it by thus drying it for many years, and made a large fortune by felling it again in dearer feafons. The life of the feed was not deftroyed by this procefs; as he afferts, that fome of it grew, which had been kept in this manner feven years; whereas in drying potatoes on a malt-kiln fo great heat was employed as to deftroy their life, and violent putrefaction enfued, as mentioned in Sect. X. 9. 2.

2. A due ventilation alfo, where corn is kept in the common warmth of the atmofphere in this climate, is neceffary, except in feafons of froft, and alfo the admiffion of light; as otherwife the vegetable mucor, called mould, is liable to grow upon the corn, and injure it; as this mucor like fome other fungufes will grow, where there is little or no change of air, and without light, as in cellars, if there be fufficient moifture and warmth.

3. Another method of preferving feeds may confift in fecluding them

them from heat, as in granaries beneath the foil ; which are fo deep or fo well covered with earth, as not to be affected by the difference of feafons. Thus there have been inftances of muftard-feed producing a crop on digging up earth, which had not been removed for many years, and, as was believed, even for ages. And in ice-houfes it is probable, that not only feeds might be long preferved, but perhaps fruits alfo ; if they were afterwards very gradually thawed by putting them into cold water, that they might not be deftroyed by the too great ftimulus of fudden heat, as mentioned in Sect. XV. 4. 1.

4. Where it has been neceffary fuddenly to collect and to preferve great heaps of corn without fhelter for the provifion of armies, fome have moderately moiftened the upper furface of the heap daily, which has occafioned the upper grains to grow, and thus to produce a fward or turf over thofe below ; which, it is faid, has thus preferved the lower part of the magazine. But in refpect to granaries for the purpofe of laying up very large quantities of grain to prevent famines in fcarce years, I fuppofe the ftacks of covetous farmers, who keep their corn in cheap years, hoping to fell it at a better price in fcarce ones, is a more certain method, and a cheaper one to the public, to keep up a fufficient ftock of corn, than by any other experiment that can be devifed.

5. Gardeners in general prefer new feeds to old for their principal crops, as they are believed to come up fooner, and with greater certainty, and to grow more luxuriantly. " But peas and beans of a year old," Mr. Marfhall obferves, " are by fome preferred to new, as not fo likely to run to ftraw. And cucumbers and melons are beft to be feveral years old, in order to their fhooting lefs vigoroufly, and thence becoming more fruitful. But this principle is carried too far by fome gardeners, who fay thefe feeds cannot be too old, and will allow ten years to be within bounds ; three for cucumbers, and four for melons, however is age enough.

" As to the age of feeds, at which they may be fown, it is uncertain, and depends much upon how they are kept; thofe of cucumbers and melons are good a long time, becaufe very carefully preferved.

"Peas and beans will germinate very well at feven years of age; but the feeds of lettuces and kidney-beans, and fome others, are not to be depended upon after a year or two; and generally fpeaking the fmaller feeds are of the leaft duration." Marfhall on Gardening.

6. Where feeds of a perifhable nature are to be carried to, or brought from, diftant countries, I fufpect that covering them in fugar would be the moft certain and falutary method of preferving them; and even, that flefh meat cut into thin flices, and covered with fugar, or fyrup, or treacle, would be better preferved than in brine, and afford a much more falutary nourifhment to our failors.

Since I wrote the above I have feen a paper in the Tranfactions of the Society of Arts, Vol. XVI. from Mr. Sneyde of Belmont in Staffordfhire, who having obferved fome feeds, which came accidentally amongft raifins, to grow readily, directed many feeds to be fent from the Weft Indies covered with raifins, and others in fugar, and others in the ufual manner of fending them, and found, that thofe immerfed in fugar or covered with raifins both looked well, and grew readily; whereas many of the others would not vegetate.

Since the powder of frefh burnt charcoal is known fo powerfully to abforb all putrid vapours, it is probable the feeds mixed with and covered with charcoal duft, which has been recently burnt, or not long expofed to the air, might be fuccefsfully employed for the prefervation of feeds either in long voyages, or in domeftic granaries.

VIII. 1. *To fow feeds advantageoufly* it is probable, that thofe of our native plants might be fuffered to drop on the furface of the earth in the autumn, as they fall from their parent plants, covered only by their deciduous leaves; in which fituation their fruit might contribute to nourifh them, as our crabs and floes; or defend them from infects, as the acrid hufk of the walnut; or from birds, as the hard ftones ſtones or ſhells of nuts and cherries, ſince this is the proceſs of nature.

But when the ſeeds brought originally from other climates are to be ſown, an attention is required to the circumſtance of ſeaſon and of ſoil. Thoſe, which will ripen their ſeeds in the ſame year, are to be ſowed in the early ſpring, and covered lightly with earth to preſerve them from birds and inſects; and ſhould be buried thus beneath the ſoil, ſoon after it has been ploughed or dug, as its interſtices are then replete with atmoſpheric air; which may be neceſſary to ſtimulate into elevation the plume of the embryon plant; as the moiſture of the earth is neceſſary to ſtimulate the root into its elongation downwards.

Thoſe ſeeds nevertheleſs, which will not perfect their vegetation in the ſame year, muſt be ſown in the early autumn; and though all ſeeds vegetate better, when placed but a little beneath the ſurface of the ſoil, as one inch, becauſe they have then a better ſupply of atmoſpheric air, which may be neceſſary for their firſt growth, before they have acquired leaves above ground; yet as many foreign ſeeds may not be ſufficiently hardy to bear our inclement winters, it may be neceſſary, as ſome believe, to bury them an inch and a half, or two inches, deep in the ſoil, to prevent the froſts from doing them injury, as well as to preſerve them from the depredation of birds. And the drill ſemination, or ſowing all kinds of ſeeds in rows, is the moſt convenient method for ſowing them at a determined depth, and alſo for the purpoſe of keeping the young plants clear from weeds by the more eaſy application of the hoe.

To ſow many ſeeds earlier than is uſually practiſed is much recommended. There is a paper by Lord Orford in Mr. Young's Annals of Agriculture, Vol. IX. p. 385, who ſeems to have found conſiderable advantage by ſowing barley ſo early as the ſeventh of February, three and a half buſhels on an acre. But as much moiſture with or without ſubſequent froſt is more liable to deſtroy the embryon

bryon in its very early ftate in the feed, than after it has fhot out roots and a fummit, and thus acquired fome habits of life; this early fowing muft fometimes be practifed with caution. Seeds may neverthelefs be fown ftill earlier in hot-houfes, or in warm fituations, as peas, beans, wheat, and may be afterwards tranfplanted in the vernal months with fafety and advantage. See Sect. X. 3. 6.

The difficulty of determining the beft feafon for fowing feeds in the fpring, owing to the variation of the weather in the fame latitude, as well as in laying down the exact feafons for fowing in different latitudes, occafioned Linneus to conftruct, what he terms a calendar of Flora; which was afterwards adapted to this climate by Stillingfleet; which confifted in obferving the firft appearance of the rootfcions, or flowers of the uncultivated native vegetables; with directions to fow the cerealia, or harveft feeds, when fuch plants or flowers became vifible. By attention to fuch obfervations on the uncultivated native plants in many climates, it is probable, that ingenious tables might be produced, which might direct the beft time of fowing the ufeful feeds in all latitudes, and in all fituations.

Another table of the climates, where plants grow naturally, and of their native fituations in refpect to moifture or drynefs, hill or valley, with the kind of foil where they were originally found, might alfo contribute to their fuccefsful cultivation.

2. In the gardens near large towns, where the land is more valuable and better manured, gardeners fometimes fow two or three kinds of feeds on the fame ground for the purpofe of economy. Thus Mr. Marfhall obferves, that "on the fame ground they fow radifhes, lettuces, and carrots; the radifhes are drawn young for the table, the lettuces to plant out, and a fufficient crop of carrots is left; for carrots, if you wifh them to be large, fhould not grow very near to each other."

In defence of this mode of culture it is faid, if one crop fails, the others may do well, and there is no lofs of ground or time; and if

all

all fucceed, they do very well. Radifhes and fpinach are commonly fown together by the common gardeners, and many manœuvres of inter-cropping are made by them, as the fowing or planting between rows of vegetables that are wide afunder, or prefently to come off, or in the alleys of things cultivated on beds.

"Thus if a piece of horfe-radifh be new planted, it may be top-cropped with radifhes or fpinach, &c.; or if a piece of potatoes be planted wide, a bean may be put in between each fet in every or every other row; a thin crop of onions upon new afparagus beds, is a common practice, drawing them young from about the plants." Introduc. to Gardening. Rivington.

The farmer likewife, in the cultivation of graffes for feeding fheep, finds an advantage in fowing a mixture of feeds on the fame ground, as rye-grafs, trefoil, and clover, which are faid to fucceed each other in refpect to the production or maturity of their herbage, as in Sect. XVIII. 1. 1. And for the purpofe of preventing fmut it may be ufeful, as I have before obferved, to fow in the fame ground in feparate rows two kinds of wheat, one of a forwarder nature than the other; whence if the farina of one kind fhould be injured by wet weather, that of the other may impregnate the ears of both. The two kinds of wheat recommended are bearded wheat and fmooth-headed wheat, which are called by farmers cone wheat and Lammas wheat; of both of which there are many varieties, and it is afferted that one third of cone wheat is frequently fowed with two thirds of Lammas wheat, and that the crops are much fuperior to either of them feparately. Hall's Encyclop. Art. Agriculture.

In refpect to kinds of foil thofe fhould be chofen, which have been found by obfervation to fuit particular feeds, both in regard to their nutritive properties, and the moifture and warmth of their fituations. And for thofe feeds, which produce tuberous roots within the earth previous to their flowering, as potatoes, parfnips, radifhes, a foil of lefs cohefion fhould be found or prepared.

3. Add

3. Add to this, that there are ſome ſeeds, as thoſe of carrots, that are ſo difficult to be diſſeminated in uniform quantities, that it has been cuſtomary to mix them previouſly with ſand or garden mould, for the purpoſe of giving them weight, or bulk, or to detach them from each other. And ſome even ſuffer them to begin to put forth their roots in ſuch a mixture of moiſt ſand or garden mould for the purpoſe of more regularly diſperſing them.

In dry ſeaſons the ſoaking ſeeds in water, a day or two before committing them to the ground, will forward their growth, as well as by artificially watering the ground before or after ſowing them; and the ſoaking them in a ſolution of ſalt and water may have another advantage of giving an opportunity of rejecting the light ſeeds, which float, and perhaps of deſtroying ſome inſects which may adhere to them; the ſprinkling ſome kinds of ſeed with lime may alſo be of advantage for the purpoſe of deſtroying inſects, if ſuch adhere to them, and of attracting moiſture from the air, or lower parts of the earth, or for its other uſeful properties; but where the ſeed, ſoil, and ſeaſon, are adapted to each other, none of theſe condiments are required.

It may neverthelefs on other accounts be very advantageous to ſteep many kinds of grain in the black liquor, which oozes from manure heaps. Mr. Chappel, in the papers of the Bath Society, found great benefit by ſteeping barley in the fluid above mentioned for twenty-four hours, and ſkimming off the light grains. On taking it out of the water he mixed wood-aſhes ſifted with the grain to make it ſpread regularly, and obtained a much finer crop, than from the ſame corn ſown without preparation. To this we may add, that to ſteep the ſeed in a ſolution of dung in water, as in the draining from a dung-hill, is believed in China both to forward the growth of the plant, and to defend it from variety of inſects, according to the information given to ſir G. Staunton.

There is an old proverb, "ſow dry and ſet wet;" but where the

4 earth

earth has been lately turned over by the plough or ſpade, there can be no bad conſequence from ſowing during rain in general; but in ſome clay grounds much ſoftened by rain, if ſeed be put into holes, and a dry ſeaſon ſucceeds, an impenetrable cruſt may ſupervene by the exhalation of the water, and the ſetting, as it is called, of the clay; but even this could not frequently occur, when ſeeds are ſown in the moiſt weather of the autumnal months; but generally in both caſes the growth of the ſeed would be forwarded by the moiſture.

4. Where the fruit, which ſurrounds any kind of ſeeds, can be ſowed along with them, it may anſwer ſome uſeful purpoſe. Thus the fruit of crabs, quinces, and ſome hard pears, will lie all the winter uninjured covered only with their autumnal leaves, and will contribute much to nouriſh their germinating ſeeds in the ſpring. So the holly-berry and the ivy-berry remain during the winter months uninjured by the rains or froſts, and undevoured by birds or inſects, and contribute to nouriſh their germinating ſeeds, when they fall on the ground in the ſpring. The acrid huſk of walnuts ſowed along with them preſerves the ſweet kernel from the attack of inſects; the ſame muſt be the uſe of the acrid oil of the caſhew-nut. The hawthorn poſſeſſes both a nutritive covering and a hard ſhell for the above purpoſes; and the ſeeds of roſes are armed with ſtiff pointed briſtles, as well as furniſhed with a nutritious fruit, ſo long known as an agreeable conſerve in the ſhops of medicine, conſerva cynoſbati; the former conſtitutes a defence againſt inſects, and the latter ſupplies a reſervoir of nutriment for the germinating ſeeds.

5. To this ſhould be added, that in our ſhort and cold ſummers the viviparous buds of ſome vegetables are too luxuriant, and do not produce oviparous buds ſoon enough to ripen their ſeeds, as melons and cucumbers, and many other plants, in thoſe ſeaſons which are moiſter than common. It is believed, that by waſhing the ſeeds of melons and cucumbers from the ſaccharine and mucilaginous matter of their fruit, and by keeping the ſeed three or four years before it is uſed,

that the viviparous buds become lefs vigorous, and the oviparous ones more numerous, and forwarder in their flowering; and for the production of earlier as well as of larger crops all fuch luxuriant vegetables fhould be fown early in the vernal feafon, or in the autumnal months, if they are not too tender to bear the winter frofts.

IX. *Queftion concerning general enclofure.*

The political advantage or difadvantage of the general enclofure of a country belongs to this place, as it more particularly affects the production of the cerealia, or corn-agriculture.

There can certainly be no objection to the enclofure of commons, or at leaft to the divifion of them into private property, as they are believed to produce more than tenfold the quantity of fuftenance to mankind, if they are employed in agriculture, or even in pafturage, than by nourifhing a few geefe, fheep, or deer, in their uncultivated ftate covered with fern, heath, or gorfe.

2. The advantage of enclofing pafture-lands, or meadows, can not be doubted; as the management of fattening cattle, of milch-cows, fheep, and horfes, becomes fo much eafier; as well as the more convenient ufe of the aftermath, when the hay is carried away.

3. The lands alfo appropriated to the production of garden vegetables and fruit, as well as to the production of other perennial plants, which are ufed in the arts, as hemp, flax, madder, woad, rhubarb; and of the efculent roots or herbage raifed for the confumption of cattle, as turnips, potatoes, carrots, cabbages, certainly require to be enclofed.

4. The political queftion therefore finally concerns only the arable lands, and afks fimply, whether a general enclofure of arable lands be favourable or unfavourable to the population, and confequent profperity of the country, which muft depend on the comparative quantity of nutritive provifion, which is likely to be produced from the different modes of its cultivation.

6 Now

Now as paſturage requires fewer hands in the management of it, and leſs art and attention to conduct it, than agriculture ; and as its products in fleſh, cheeſe, butter, take a higher comparative price at market, and are articles of greater luxury, than the products of arable land in corn, we may conclude, that paſturage will prevail in all encloſed provinces over agriculture. And as perhaps tenfold the numbers of mankind can be ſupported by the corn produced on an hundred acres of land, than on the animal food which can be raiſed from it, it follows, that an encloſed province will afford ſuſtenance to a much ſmaller population; and as the number of inhabitants of a country depends on the eaſe, with which parents can procure ſuſtenance for their families, marriages will become fewer, and the people decreaſe, when an arable country is converted into paſturage.

This laſt circumſtance appears already to operate in theſe realms, ſince about half a century ago much corn was exported annually, but for ſeveral years laſt paſt great quantities of it have been annually imported for our own ſuſtenance; and that even though potatoes are much cultivated, and muſt therefore leſſen the conſumption of grain, and the ungraceful faſhion of covering the head with wheat-flour is much diminiſhed. Is this to be ſolely aſcribed to the numerous encloſures of arable lands, or in part to the conſumption of corn in the diſtilleries ?

One very important conſequence of any country producing a greater quantity of corn, than it conſumes, and of thence exporting it to foreign nations, even by means of a bounty, conſiſts in its certainty of preventing famine, the moſt dreadful of human calamities; as in years of ſcarcity the ſtream of exportation can be ſtopped, and produce an ample ſupply by its ſtagnation at home.

Hence when a great part of any tract of country becomes employed in paſturage inſtead of agriculture, the inhabitants will become conſumers of fleſh inſtead of conſumers of grain, and will conſequently decreaſe in number from the want of ſufficient ſuſtenance.

Befides which the people of agriculture are more active and robuft than the people of pafturage, and more ingenious in the invention and ufe of machines neceffary for the more artful cultivation of the foil, as well as more numerous, and will confequently become fuperior to them in arms and arts, and may in procefs of time conquer them; which reminds us of the Egyptian Dynafty of Shepherd-kings, who were fubdued by their agricultural rivals; and alfo of the allegorical hiftory of Cain flaying Abel, which were probably the names of two political hieroglyphic figures reprefenting the ages of pafturage and of agriculture before the invention of letters.

It muft hence certainly be an object of good policy to encourage agriculture in preference to pafturage, which in this country might be effected by preventing the enclofure of arable lands, and alfo of thofe parts of commons, which are beft adapted to the growth of corn; though the whole might be advantageoufly divided into private property. Unlefs fome other means could be devifed of preventing a nation from becoming too carnivorous, or of duly promoting the cultivation of grain, the former of which was heretofore produced by religious faft-days twice a week, and the latter by bounties on the exportation of corn. To which might be added a total prohibition of the deftructive manufactory of grain into fpirits, or into ftrong ale, and thus converting the natural nutriment of mankind into a chemical poifon, and thus thinning the ranks of fociety both by leffening their quantity of food, and fhortening their lives by difeafe.

In many villages, where much arable lands have been lately enclofed, the numbers of labouring people have quickly been much diminifhed both by the fcarcity of food, and want of employment.

> Worfe fares the land, to haftening ills a prey,
> Where wealth accumulates, but men decay;
> Princes or lords may flourifh, or may fade,
> A breath can make them, as a breath has made;

But

But a bold peafantry, their country's fword,
When once deftroy'd, can never be reftor'd.
Goldsmith's Deserted Village.

Mankind neverthelefs feems by nature to be defigned to fubfift on both vegetable and animal nutriment, which appears from the length of his inteftines, which like thofe of fwine are much longer than the inteftines of carnivorous animals, and much fhorter than thofe of the vegetable eaters; and which alfo appears from the ftructure of his teeth, which partakes of the ftructure of thofe of the carnivorous and phytivorous animals; and laftly, becaufe thofe people, who live folely on vegetables, as the Gentoo tribes, and thofe who fubfift folely on animals, as the fifh-eaters of the northern latitudes, are undoubtedly a feebler generation than thofe of this country, who exift on a mixture of both. A due proportion therefore of the two kinds of nourifhment, fuch as perhaps at prefent exifts, or lately did exift, in this nation, muft be decidedly the beft; the prefervation of which, with the prohibition of fpirits, or of ftrong fermented liquors, except occafionally as medicines, might probably render thefe kingdoms more populous, robuft, profperous, and happy, than any other nation in the world. But if the luxurious intemperance of confuming flefh-meat principally, and of drinking intoxicating liquors, fhould increafe amongft us, fo as to thin the inferior orders of fociety by fcarcity of food, and the higher ones by difeafe both of mind and body, it may hereafter be faid of Great Britain, amid her foreign conquefts, as formerly of ancient Rome,

——————— Sævior armis
Luxuria incubuit, victumque ulcifcitur orbem.

SECT.

SECT. XVII.

PRODUCTION OF ROOTS AND BARKS.

Barks of trees are ſimilar to their roots. All roots now known were originally from ſeeds. I. 1. Tuberous or bulbous roots *of turnip, carrot, parſnip, beet, are reſervoirs of nutriment for the future ſtem. Not ſo in graſſes. Sugar viſible in beet roots. Small beer from parſnip roots. Alcohol from carrots. The knobby root and flower-ſtem are ſucceſſive plants. Select forward ſeeds from vigorous plants, and a ſoil not coheſive. Radiſhes on hot-beds.* 2. *Tuberous roots from ſubterraneous wires, as potatoes. Pinch off the flowers. Make a cellular ſoil. Aerial potatoes. Curled leaf of potatoes. Sow the ſeed. Plant large roots and whole ones. Early potatoes.* 3. *Improve ground artichoke and pignut by ſeed.* 4. *Onions, method to improve them.* 5. *Orchis, ripen the ſeeds of it. Snow drops. Hyacinths. Crocus. Martagon lily.* II. 1. Palmated, or branching roots, *not immediately from ſeed. Perennial roots, like barks of trees, continue to increaſe in ſize. Should remain four or five years in the ground, not longer, as rhubarb.* 2. *Pinch off the flowers, as in rhubarb.* 3. *Roots of aquatic plants. Nymphæa, butomus, cultivated for nutriment, wine, or vinegar.* 4. *Art to preſerve roots. Keep them alive, between 32 and 48 degrees of heat, covered with pounded charcoal, ſaw-duſt, and thatch, or dry them by ventilation and heat.* 5. *Of muſhrooms. Their gills are their lungs. Are animate beings without locomotion. Are of animal origin. Conduct galvaniſm. Muſhroom ſtone, truffles, morels, muſhrooms with acrid juice. Ear-fungus.* III. 1. Barks *contain ſugar and mucilage, and other ingredients. They ſhould be taken off before the buds expand.* 2. *Oaks, why barked in ſpring.* 3. *Barks of elm and maple might make ſmall beer. Of holly eſculent. Bird-lime like caoutchouc.* 4. *Bitter, aromatic. Acrid barks.* 5. *Reſtringent and colouring barks for tanning and dying.* 6. *Fibrous barks of flax, papyrus, mulberry, and birch.* 7. *To increaſe the bark pinch off the flowers.*

flowers. 8. *Rub off the moſs. Sprinkle with water.* 9. *Wounds of the bark. Paint the naked alburnum.* 10. *Canker. Bind on a new bark. Plant the branch in a divided garden-pot.*

As the barks of trees are compoſed of a congeries of the long caudexes of the individual buds, which conſiſt of the abſorbent veſſels, which imbibe nutriment from the earth, and of the arteries and veins, which ſupply nutriment to the growing vegetable; of the glands, which ſecrete from the vegetable blood the various acrid, aſtringent, or narcotic, juices to defend them from the depredation of inſects; and the various mucilaginous, oily, or ſaccharine, materials for the nouriſhment of their embryon buds; and laſtly, of the organs of reproduction. There exiſts the ſtrongeſt analogy between the barks of the trunks of trees, and of their roots, in every reſpect; except that the former poſſeſſes a cuticle adapted to the contact of the dry atmoſphere, and the latter a cuticle adapted to the contact of the moiſt earth, which differ from each other like the external ſkin, and the mucous membranes of animals. And finally, as theſe long caudexes of the buds of trees, which form the filaments of the bark, terminate in radicles beneath the ſoil, and in leaves in the air, like the broad caudexes with the radicles and aſcending ſtems, or foliage, of herbaceous plants, they exactly reſemble each other.

We ſhall therefore divide roots for the purpoſe of treating of their production into bulbous or tuberous roots, into palmated or branching roots, and into barks; obſerving that though roots and buds might poſſibly have exiſted before ſeeds, and though a great number of the roots uſed for nutriment, or for the purpoſes of medicine, or for the arts of dying and tanning, are immediately produced by buds, or bulbs; yet are they all, which we now poſſeſs, originally derived, I ſuppoſe, from ſeeds; becauſe thoſe varieties, which have been propagated from buds or bulbs for many centuries, are believed to acquire hereditary diſeaſes, and gradually to periſh.

1. Of

1. *Of tuberous and bulbous roots.*

1. Some tuberous roots, as the turnip, braffica rapa, are immediately produced from feeds, but differ from the other plants, which are called annual or biennial, in this circumftance; that, as they are generally fowed fo late in the feafon as not to have time to produce flowers and feeds in the fame year, they produce a knobby root, which confifts of a refervoir of nutritious matter for the future flower-ftem, which is to rife and flourifh in the fucceeding fpring and fummer; whereas the common annual graffes, as oats and barley, do not previoufly lay up a magazine of nutriment in their roots, but in their joints, which are fweet; and therefore their roots are not ufed for culinary purpofes, or for provender.

Other tuberous roots are raifed in the fame manner from feeds, but are generally fown alfo fo late in the feafon as not to form their flower-ftems in the fame year; as the carrot, daucus carota; the parfnip, paftinaca fativa; and the beet, beta vulgaris; thefe alfo lay up a ftore of mucilaginous and faccharine matter in their roots for the growth of the future flowers. In the beet-root the cryftals of fugar are fometimes vifible by a microfcope; and I was well informed, that a labourer in Lincolnfhire made fmall beer from a decoction of parfnip roots, which was fpirituous enough, and not of difagreeable flavour; and Mr. Hornby of York, by boiling carrots, and fermenting the juice expreffed from them, produced two hundred gallons of proof fpirits from twenty tons of carrots. Edinb. Tranfact. Vol. II. p. 28. Now as all vinous fpirit has been fugar, there is foundation to hope that a method may be difcovered of producing and feparating fugar from thefe plants of our own climate in fufficient quantity for our demeftic confumption, or even for exportation.

Other tuberous roots are propagated from feeds in the fame manner; and though they are fowed early, and produce their flower-ftem and feeds in the fame year, yet they form a knobby root, which con-

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fifts of a magazine of nutritious matter, previous to the elevation of the flower-ftem, as the radifh, rhaphanus fativus, and carrot, and beet, when fown early. I neverthelefs fufpect that thefe, as well as the preceding, confift in reality of two fucceffive plants; that which forms the knobby root, and that which is formed from it, as fpoken of in Sect. IX. 3. 6.

For the production of roots of thefe kinds, which are immediately or fecondarily propagated from feeds, our attention muft be applied to collect the forwardeft feeds, and from the beft plants of the kind; and to fow them at the proper feafon of the early fpring, or early autumn; and in a foil which contains fufficient vegetable nourifhment, obferving, neverthelefs, that as carrots, parfnips, beets, and radifhes confift of knobs formed in the ground, a lefs adhefive foil is to be felected; as one abounding with filiceous or calcareous fand, as well as with carbonic earth. But as the turnips are formed chiefly above ground, this attention to the cohefion of the foil becomes lefs neceffary, fo that it is fufficiently penetrable by the fibres of their radicles.

There is another art of producing larger roots from feed, and at an earlier feafon, as of radifhes; which is by fowing them in hot-beds in the early fpring, and expofing the tops to the cold air during the day, as this prevents the luxuriant growth of the fummit, and increafes that of the root.

2. Other tuberous roots are generally propagated by fubterraneous wires, or root-buds, from the tuberous roots of their parents through a long generation, and not either primarily or fecondarily from feeds; as the potato, folanum tuberofum; and the ground artichoke, or tuberous fun-flower, helianthus tuberofus; and perhaps the pig-nut, bunium bulbocaftanum.

As the tuberous roots of the potato planted in the fpring not only produces many other fimilar tuberous roots, but flowers alfo during the fummer; I was led to fufpect, that pinching off the flowers, as they appeared, would contribute to increafe the number or enlarge the fize of the new roots; which experiment has been made on a fmall fcale by one, who believed it to fucceed in a degree decifive of its utility. See Sect. XIX. 3. 1. and Sect. VII. 1. 3, where it is faid, that pinching off the flower-ftems of bulbous-rooted flowers, when they firft appear on young bulbs only a few years from the feed, is believed to render the flower duplicate.

As the roots of potatoes are formed beneath the earth, the foil, in which they are planted, fhould be laid hollow and full of cells, or fhould poffefs lefs cohefion than ufual, to facilitate the protrufion of their wires, and the enlargement of their roots. This fhould be done by burying fome long litter of ftraw and ftable dung under the foil; for as potatoes are believed to require more carbonaceous earth than carrots, a mixture of fand is lefs advantageous to them.

I was this day fhewn by my friend Major Trowel of Derby a new variety of the potato in his excellent new-made garden, the foil of which confifts of marl mixed with lime and ftable-manure. From one root there appeared to iffue fix or eight ftems three or four feet long, at every joint of which were produced new potatoes; at the lower joints there were three of thefe aerial potatoes, one large one the fize of a pullet's egg, and a fmaller one on each fide of it. At the upper joints only one new aerial potato adhered, and thefe became fmaller the further they were removed from the root; and finally, at the fummit there had been a flower as there was now a feed-veffel, called a potato-apple. All thefe new potatoes at the joints of the ftems were green, becaufe they had not been etiolated by being fecluded from the light, but the terreftrial roots were white. The larger new tuberous roots had eyes on them like a common potato, but the fmaller ones had begun to fhoot out a new ftem or leaves from their upper part. This variety, which may be termed an aerial potato, is analogous to the magical onion, and other fpecies of allium, which bear cloves, or roots on their fummits inftead of feeds, and like the viviparous polygonum; but differs in this circumftance, that in all thofe, I believe, the flowers are barren in refpect to bearing feeds, as thofe are on the fummit of the fpike of polygonum viviparum; but in the aerial potato there was alfo a feed-bearing flower at the fummit of the ftem, and the new roots only at the lateral joints. I fhould hope this proliferous variety by cultivation may become permanent, and give rife to a new fpecies, which may produce both aerial potatoes and fubterraneous ones, a twofold viviparous progeny.

The curling of the leaves of potatoes, which is attended with fo great a diminution of the quantity and fize of the new roots, is fuppofed to be owing to their continued propagation by fubterraneous buds or root-wires, inftead of by feed; that hence they acquire hereditary difeafes, like the canker or gangrene of apple trees, which have for one or two centuries been propagated by grafting the fcions, as mentioned in Sect. IX. 3. 4. and XV. 1. 4. Hence by fowing the feeds of potatoes, and cultivating the roots thus produced, new varieties may probably be foon acquired, exempt from the difeafe of the curled leaf, and which may be as good in other refpects as thofe which have been too long propagated by their roots. Some have neverthelefs affirmed, that they have feen curled potato-plants in the fecond year from the feed; and others, that they have feen numerous infects on thefe curled leaves; and others, that the potato-root, the leaves of which are curled, remains hard, and lefs diffoluble in the foil, which I have myfelf witneffed. More obfervations are wanted to elucidate this fubject.

Another caufe of the degeneracy of potatoes has arifen, I believe, from planting the leaft inftead of the largeft roots, fee Sect. XVI. 5. and which confequently poffefs lefs vigorous vegetation, as buds and bulbs fo exactly refemble the parent plant. Thus the fmall bulbs, which arife from tulip-roots, will produce a rather larger bulb annually for three or four years, as I am informed; but it is the large new central bulb only, which will produce a flower the next ſummer, and another large central bulb like itſelf. See Sect. IX. 3. 1. Another cauſe of the degeneracy of potatoes may ariſe from dividing the larger roots into too many ſets, which muſt deprive the embryon plant of much of its appropriated nutriment; as the umbilical part of the root is generally thrown aſide by thoſe idly-ingenious diſſecters of it; for though the part, where the umbilical veſſels were inſerted, may not after the mature growth of the bulb appear to poſſeſs new veſſels from the embryon plants, ſuch as are ſeen on the lobes of a growing garden-bean; yet, as it becomes decompoſed, it muſt ſupply mucilaginous or ſaccharine nutriment to the roots of the new plants.

As the potatoes raiſed from ſeeds do not flower on the ſecond or third year, reſembling in this circumſtance the bulbs of tulips and hyacinths; theſe new roots, I am told, are ſold as early potatoes, and that they are forwarder in their growth from their being generally planted without being divided; and that they form their new roots ſooner, as they do not flower. To improve the ſeeds of potatoes ſee Sect. XVI. 3. 4.

The following method of planting whole potatoes is recommended in Mr. Adam's Eſſays on Agriculture, and has a promiſing appearance.

" The idea," ſays he, " which I mentioned before, reſpecting the culture of the Scotch and Anjou cabbages, might be ſucceſsfully applied to that of potatoes. Let us ſuppoſe the ground, in which they are to be ſet, is properly prepared by plowing: let then the furrows be drawn in it at four feet diſtance all over the field, and croſſed by other furrows at an equal diſtance. Where theſe interſect each other lay in ſome dung from a wheelbarrow, extending from the point of interſection fourteen or fifteen inches each way: let a man following ſpread a little of the mould from the furrow over the dung; let a third hand put one whole ſound potato at the point of interſection, and one in each furrow, at a foot diſtance from the centre, which will make five in all: a fourth hand ſhould now follow with a barrow full of leaves, and lay them over the plants; ſhould then ſprinkle ſome mould lightly over them, and leave them ſo till the plants ſhoot.

"Thus the plants will occupy a ſpace of two feet each way, out of the four feet between the furrows; and the remaining intervals between the plants on each ſide will alſo be two feet, which intervals I would horſe-hoe at the proper periods, firſt one way of the field, and then acroſs, laying the mould upon the plants at each hoeing, ſo that the ſpaces which the plants occupied would by theſe means become little ſquare hills filled with roots; and the intervals between being thus hoed and croſs hoed, would have the uſual good effects of pulverizing the ſoil, deſtroying the weeds, and preparing the land in the beſt manner poſſible for a crop of wheat."

3. The ground artichoke, helianthus tuberoſus, ſeldom ripens its ſeeds in this country, and might probably be much improved by uſing methods to ripen the ſeed, which are mentioned in Sect. XVI. 3. 4; and by thus producing new varieties; and the pignut, bunium bulbocaſtanum, might probably by cultivation from the ſeed ſupply an agreeable and ſalutary root to be eaten like cheſnuts either raw or roaſted.

4. The ſeeds of the common onion, allium cepa, generally produce no flower-ſtems the firſt year; but each ſeed produces concentric leaves, which gradually form a large bulb below them with one or two, and ſometimes three, leſs internal bulbs, included within three or four general concentric coats, beſides the three or four coats appropriated to the individual bulbs, as deſcribed in Sect. IX. 3. 2. On the next year ſome ſpecies of this genus produce bulbs after their flowers inſtead of ſeeds, as allium ſativum and magicum; others produce not only flowers but alſo bulbs, as allium moly, and ſpherocephalum. If the bulbs of theſe leaſt kinds of allium were planted

with

with deſign to produce other bulbs, and not to produce ſeeds; it is probable, that pinching off the flowers might enlarge the new bulbs, as the pinching off the flowers of potatoes; and that by ſuch means a larger kind of bulbs of ſome of this genus might be procured.

5. Another bulbous root, which might be well worthy cultivation in moiſt ground, is the orchis morio; which is ſold under the name of ſalep, after it has been prepared by firſt ſcalding it in hot water to detract the ſkin, and afterwards by drying it in an oven; and which then affords a nouriſhing mucilage, which will long keep uninjured. And, if it was cheaper, might probably be brought into more extenſive uſe as a culinary vegetable, as mentioned in Sect. XVI. 3. 4. The orchis morio produces one large new root annually, and probably ſome ſmaller offsets, as otherwiſe I do not perceive, how it could increaſe in our meadows, as it does not ripen its ſeeds in this country.

If the new root be taken away from the old one early in the year, it is affirmed, that the ſeeds will ripen in Sweden; which are otherwiſe in that country, as in this, always unprolific; this experiment might therefore be very advantageous to the cultivator. Another method of inducing orchis to bear prolific ſeeds may be by confining the roots in garden pots, which might be immerſed in a moiſt ſoil, and would probably bear ripe ſeeds; as the lily of the valley, convallaria, is ſaid to do by crowding its roots ſo much as to prevent the production of more of them, Amenet. Academ. Vol. VI. p. 120. A third method of procuring ſeed from orchis might be by cultivating a few of them in a hot-houſe for that purpoſe.

The root of the ſnow-drop, galanthus, if dug up in winter, and prepared in the ſame manner, might poſſibly ſupply a nutritious mucilage ſimilar to that of the orchis; as I once boiled a few of them, and found on taſting them, that they had no diſagreeable flavour. If prolific ſeeds could be procured from this plant, it might be worth cultivation for the ſame purpoſes as the orchis; and the roots of the

hyacinth,

hyacinth, I am informed, are equally infipid, and might be ufed as an article of food; but the roots of crocus, which I boiled and tafted, had a difagreeable flavour, and might probably therefore be infalubrious.

Mr. Gmelin in his Hiftory of Siberia afferts, that the roots of the lilium martagon are ufed as food in that country; and it is probable, that the root of the arum, though it be acrid in its raw ftate, might fupply palatable and falutary nutriment by cookery; as Mr. White afferts in his Hiftory of Selborne, p. 43, that it is fcratched up and eaten by thrufhes in fevere fnowy feafons, and it is known foon to lofe its acrimony even by expofing its dry powder to the air; we may add, that the root of the afphodelus ramofus is ufed to feed fwine in France, and that good ftarch is obtained from the roots of white bryony and of alftromeria licta.

Other bulbous roots are propagated by florifts with great attention for the beauty of their flowers, as tulips, hyacinths, lilies, and many others. For an account of fome of thefe fee Sect. IX. 3. on the growth of bulbs, and Sect. XIX. 3. 1. on the production of flowers.

II. *Palmated or branching roots.*

1. The bulbous and tuberous roots already mentioned were either fuch, as were primarily derived from feeds, as the turnip, carrot, parfnip, radifh, beet, falfafi; or fuch as were fecondarily derived from feeds, but immediately from bulbs or knobs fimilar to themfelves, as potatoes, ground artichoke, orchis, pig-nut. But the branching or palmated roots, which are ufed as food, or in medicine, or in the arts of dying, are feldom produced immediately from feeds, but generally from preceding roots, and are hence the product not of annual but of perennial plants; as the root of liquorice, glycyrrhiza; of marfh mallow, alcea; of rhubarb, rheum; and of madder, rubia tinctoria.

The roots of thefe perennial plants fhoot out not only annual ftems ſtems with numerous flower-buds above ground, but alſo other new buds on their caudex, or upper part of the roots beneath the ſoil; all which buds protrude their new caudexes not only over thoſe ſtems, but alſo over the old root-branches; and thus form annually a new bark over the old root, which remains alive beneath the ground, though the ſtem periſhes by the winter froſts. This happens exactly in the ſame manner as the bark of trees, which annually is produced over the old bark of the root as well as of the trunk; but in trees the ſtem-bark as well as the root-bark ſurvives the winter.

Hence theſe palmated or branching roots of perennial herbaceous plants, as of rhubarb, madder, liquorice, continue to increaſe in ſize by the ſuper-addition of an annual new bark; but in four or five years the internal part begins to decay, and the roots therefore ſhould be taken out of the ground for uſe before that time. It is ſaid in the tranſactions of the Society for Encouragement of Arts, Vol. XVI. p. 226, that thoſe rhubarb roots, which were not taken up, till they were ſeven or more years old, were moſt of them good for nothing from the decay of the internal part of the root. The ſame is ſaid to happen to ſome bulbous roots, as the hyacinth; and occurs in all thoſe roots, which are ſaid to be end-bitten, as a ſpecies of ſcabius called devil's-bit. See Sect. IX. 3. 5.

They ſhould then be taken up in the winter months, before the new buds or flower-ſtems begin to acquire nouriſhment from the root, by which it would be deprived of a part of the nutritious, colouring, or medical matters; which principally reſide in the bark, or alburnum of it. On this laſt account alſo theſe roots ſhould not be permitted to continue in the ground a much longer time than that above mentioned, though the internal or woody part of the root may not decay; as the woody part is leſs adapted to the purpoſes expected than the bark and alburnum, which cover or conſtitute the numerous branches of the root.

2. One method to increaſe the ſize of theſe palmated or branch-

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ing roots may be by pinching off the flowers, as ſoon as they appear, when the ſeeds are not wanted; this I once ſaw practiſed on the rheum palmatum with apparent advantage, as well as on potatoes, as mentioned above; as more nutriment may thus be derived to the new buds forming on the roots.

The colouring matter ſold under the name of annotta, or arnotta, which is ſaid to be obtained from the ſkin of the kernel of the bixa of South America, or of the enonymus ſhrub cultivated in our gardens, is believed to be much adulterated with madder, rubia tinctoria; the root of which for the purpoſe of colouring cheeſe may be uſed inſtead of arnotta, and is to my knowledge a perfectly harmleſs root, though it tinges the bones of young animals red, who eat it mixed with their food, and may be grown by cheeſe-farmers in their own gardens, as it is a very hardy perennial plant, and requires no art of cultivation. It may be uſed either by pounding the freſh root and boiling it in water, or by drying the root for the purpoſe of preſerving it, and afterwards bruiſing and boiling it.

For the cultivation of rubia tinctoria ſee Miller's Gardener's Dictionary, who deſcribes with ſeveral plates the manner of growing and of afterwards preparing this root in prodigious quantities in Holland; and adds, "that if the cultivation of madder was carried on properly in England, that it would not only ſave to the nation the great annual ſum now expended in the purchaſe of it from the Dutch, but would employ a great number of hands, from the time harveſt is over, till the ſpring of the year, which is generally a dead time for labourers; and the pariſhes might thence be much eaſed of the poor's rates, which is a conſideration well worthy public attention."

The external part of the root of rubia tinctoria is coloured red, and its internal part yellow, which diſtinguiſhes it from moſt other roots, which are generally etiolated owing to their ſecluſion from the light; which liberates their ſuperfluous oxygen, which otherwiſe deprives them of colour as in bleaching, by uniting with their colouring mat-

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ter, and converting it into a colourlefs acid, except where the colouring matter abounds in too great quantity. This etiolation of moft roots is evidently owing to the want of light, becaufe many of them, as of white potatoes, become green if they grow above ground.

3. The roots of fome aquatic plants are ufed in medicine both of the bulbous and palmated kinds, as fcilla maritima, fquill or fea-onion, and the iris luteus, yellow water flag, and the acorus calamus, aromatic flag. Other aquatic roots are faid to have fupplied food, as the ancient lotus in Egypt, which has been by fome writers fuppofed to be the nymphæa nelumbo. Herodotus affirms in his Enterpe, that the Egyptian lotus grows in the Nile, and refembles a lily; and that the natives dry it in the fun, and take the pulp out of it, which grows like the head of a poppy, and bake it for bread. The white-flowered and the yellow-flowered nymphæa of our ponds and rivers has a palmated root fometimes three inches in diameter. In Siberia the roots of the butomus, flowering rufh, are eaten; both which well deferve further attention, as they grow fpontaneoufly in our ditches and rivers, which at prefent produce no efculent vegetables, and might thence become an article of ufeful cultivation. See Sect. IX. 2. 5.

Some other aquatic roots, as well as terreftrial ones, might probably become efculent and nutritive by boiling or roafting them to deftroy their acrimony. Or it is probable, that a wholefome ftarch might be obtained from them, as from the roots of white bryonia, as is affirmed by M. Parmetier, by the fimple procefs of grating the root by a bread-grater of tinned iron into cold water, and depriving it of its acrid mucilage by frequent cold ablution. And laftly, that they might be fo managed as to undergo fermentation either by previous germination, or by adding yeft to the juice expreffed from them after boiling, and thus be converted into wine or beer, from which a fpirit might be diftilled, or vinegar produced. See Sect. XI. 2. 5.

4. The art of preferving roots, when taken out of the ground, confifts

confifts either in keeping them alive during the winter without fuffering them to germinate, as life prevents the fermentation or putrefaction of their juices; or fecondly, by depriving them of their water. For the firft purpofe the roots, whether bulbous or palmated, fhould be kept in a degree of heat above the freezing point of 32; fince freezing them deftroys their life; whence they not only undergo a fudden change in their flavour and nutritive quality, but quickly tend to putrefaction in confequence of their lofs of life like the eggs of animals. Neverthelefs both vegetable and animal products, as fruits and flefh, as well as roots, may probably long exift unchanged in a frozen ftate in ice-houfes; and if they are at length gradually thawed by covering them with melting ice, or immerfing them in cold fpring water, it is faid by Mr. Reaumure, who tried the experiment on apples, that they do not lofe much of their flavour, if they be afterwards foon made ufe of; otherwife, I fuppofe, as the froft has deprived them of life, they foon begin to undergo chemical changes.

If thefe roots are kept in a degree of heat above 48, which is the heat of the internal parts of the earth, and confequently of fpring water, they are liable to germinate, as happens to onions and potatoes in our ftore-houfes during the vernal months. And if they be expofed to a much greater heat, fo as to deftroy the life of the root, they foon run into fermentation or putrefaction, or become covered with mould; unlefs the water which they contain be quickly diffipated by evaporation. A friend of mine once fent many ftrikes of potatoes to be dried on a malt-kiln, hoping by that means to preferve them during the fummer; but as the life of thefe roots was deftroyed by the degree of heat, and only about half of their water evaporated, they foon became fo putrid after being returned into his ftore-room, that the ftench of them was intolerable, and even the fwine refufed to eat them. Neverthelefs I believe, if the parts either of vegetables or animals could be kept in an heat at or above the boiling point of 212 in clofe veffels, fo as not to fuffer their fluid part to evaporate, that neither fermentation nor putrefactiou would enfue; but that they might be kept for years unchanged, as in the cold of 32.

The degree of heat required for preferving roots fecure from froft, and from the procefs of germination, which is that between the degrees of 32 and 48 of Farenheit's thermometer, may be well managed by ftoring them beneath the foil in dry fituations, as in dry cellars, or in pits dug for that purpofe, or even in barns; but this requires more attention than is ufually employed in the common manner of ftoring potatoes, which are liable to be injured both by froft and by germination. Thefe pits in a dry foil fhould be covered with materials, which conduct heat ill, and alfo with fuch as might abforb any putrid exhalations, which may occur, and thus check the progrefs of putrefaction, if it fhould commence.

Air is a bad conductor of heat, if it be confined over the furface of any body, but not fo if it be perpetually changed; as it then carries away heat very rapidly, as any one may experience by being fanned on a hot day. Hence all fuch materials as poffefs large pores or interftices full of air, are bad conductors of heat; as blankets, faw-duft, wood-fhavings, or ftraw; and will thence preferve the bodies, they cover, both from external cold and from external heat. But as charcoal in coarfe powder not only includes much common air in its pores, but alfo has the property, efpecially if recently burnt, of abforbing putrid exhalations; and is alfo itfelf of an unperifhable nature; it feems peculiarly adapted to the purpofes above mentioned. Hence the heaps of potatoes, or carrots, or parfnips, or ground artichokes, or even the roots of turnips or of beets, and the heads of cabbages, and perhaps pears, and apples, as well as nuts, almonds, and walnuts, might be well preferved in pits or cellars, or even in barns, if they were firft covered with powdered charcoal an inch or two in thicknefs, and over that a covering of faw-duft, and finally over thefe a thick impenetrable thatch of ftraw; whence a ftore of provender for the winter months and the fucceeding fpring

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may be preferved from any degree of cold or of warmth much above or below that of the internal parts of the earth, in which feeds are known to continue for ages even without germination or decay.

It is neverthelefs neceffary to dry many palmated roots, when they are taken out of the ground, either becaufe they will not continue to live in our barns or ftore-rooms, like the bulbous roots, or becaufe they require to be kept for fome years in the fhops of medicine. Some of thefe roots, as thofe of rhubarb, are faid like the bulbous roots of fcilla or fquill to contain five fixths of their weight of water, and therefore require confiderable care in the method of drying them; for unlefs they are properly dried, they are liable to contract mould or mucor; which is a vegetable production, which will grow on putrefying materials without light or much air; but might be prevented from growing by the vapour of perhaps a teafpoonful of fpirit of wine, as mentioned in Sect. XV. 2. 3.

There is neverthelefs fome precaution neceffary in exhaling the moifture of thefe roots, as they fhould be placed in a fituation, where they are ventilated as well as heated; for warmth alone is liable to forward the tendency of the faccharine and mucilaginous parts of them to pafs into fermentation or putrefaction, and thence to deftroy them; as the alburnum or fap-wood of timber trees is liable to decay by what is termed the dry rot.

With this defign drying houfes are conftructed for the preparation of madder, rubia tinctoria, as defcribed in Miller's Dictionary; and the rhubarb of the fhops has frequently large holes bored through it; which, it is fuppofed, were defigned to pafs cords through for the purpofe of fufpending it to dry, as it is conveyed on camels in a warm climate.

5. The cultivation of mufhrooms, morels, and truffles, agaricus, phallus, lycoperdon, fhould be here mentioned; as they are propagated by their roots. The fungi feem to conftitute an ifthmus between the two great continents of nature, the vegetable and animal kingdoms.

kingdoms. The odour of a fungus, when burning, approaches to that of burning feathers; and all of them putrefy like animal flefh; fome of them as the phallus impudicus, ftink-horn, emits fuch a putrid fcent, as it grows, as to attract innumerable flefh-flies to depofit their eggs or fpawn in it. And thofe mufhrooms, which are cooked at our tables, as well as the catchup, made by preferving their juices in falt and water, poffefs an animal flavour. Of this laft circumftance I was told a remarkable inftance, where a cook-maid in a family of invalids, who frequently wanted weak broth, perpetually deceived them by a mixture of a fmall quantity of good catchup with thin gruel, and with only the addition of fhred leaves of parfley, and a little falt.

Another thing in which the fungufes differ from vegetables, confifts in their growing perfectly well without light, which is fo neceffary to the health of vegetables. The fcarlet folds beneath the head of the common efculent mufhroom are fo like the gills of fifh, that they have in our language obtained the fame name. Thefe folds beneath the hat of the agarics, the pores beneath the boletus, and the thorny appearance beneath the hydnum, and the net-like pores of phallus, are all different means of expofing a larger furface to the air; and therefore undoubtedly conftitute the lungs of the fungufes, as leaves conftitute thofe of vegetables, and not their organs of reproduction, as fome have fuppofed.

The chemical analogy, which exifts between fome of the mufhroom tribe and animal matters, led Van Humboldt to inveftigate their conducting power of what he terms the galvanic fluid, which I believe to be fimply a minute fhock of the electric fluid; and he found, that morels and thofe fungi, which in a ftate of putrefaction emit a cadaverous animal fmell, are equally good conductors as real animal fubftances. Annals of Medicine for 1798, Edinb. Van Humboldt afferts further, that by chemical analyfis they approach likewife to animal fubftances, as they contain much azote and phofphorus. He alfo afferts, that he converted morels into fat by means

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of ſulphuric acid diluted with water, which experiment he thinks is analogous to that of Gibbes, and of the burying ground of the Innocents, where fat was formed from muſcular fleſh. Journal de Phyſique, Vol. IV. p. 67.

The fungi would hence appear to be animals without locomotion, whoſe lacteal veſſels are inſerted into the earth, like thoſe of vegetables; but whoſe gills or lungs are covered from the light, like thoſe of animals, but expoſed to the open air like the leaves or lungs of vegetables. Another curious occurrence, which ſeems to aſſociate them with animals, if the truth can be depended upon, is that ſome of them are of animal origin; as the common muſhroom is ſaid certainly to be procured from horſe-dung, as mentioned below; and may therefore have its embryon or early ſtate in the inteſtines of animals, and its maturer ſtate in the ſoil or atmoſphere like other inſects, as the bot-fly, and perhaps the tape-worm, and aſcarides? as this production of muſhrooms is otherwiſe contrary to all known analogy. Other fungi are found on the decayed parts of peculiar vegetables, from which they ſeem to take their origin, perhaps like worms in the inteſtines of animals, as the agaric of the oak, of the beech, of the elder; the boletus of the beech, and of the willow; and many others mentioned by Linneus.

The lycoperdon tuber, or truffle, grows under ground without light, never riſing into day; and is propagated, I ſuppoſe, by only a paternal or lateral progeny, like the polypus of our ditches, and not by ſexual connexion, or ſeminal progeny. The truffle is hunted by dogs probably from its poſſeſſing ſomewhat of an animal ſcent, like the perſpirable effluvia left upon the ground, by which they hunt their game or diſcover the foot of their maſter.

The phallus eſculentus, morel, and the agaricus, muſhroom of various kinds, will grow without light in cellars, or on beds covered with ſtraw; and are alſo, I ſuppoſe, propagated by a paternal or lateral progeny only, and not by a ſexual or ſeminal one.

The roots, or ſpawn, or embryons, of the common muſhroom are ſaid by Mr. Kenedy and others to be certainly procured from horſe-dung laid unbroken in ſmall heaps under cover. It is aſſerted, that in a few weeks during the ſummer months theſe roots will appear like white threads; which on breaking the lumps have the muſh-room ſmell. Theſe horſe-droppings are directed to be as little broken as poſſible, and to be laid about three inches thick on a hot bed of moderate warmth, conſtructed of alternate layers of tanner's bark and horſe-dung, and whoſe uppermoſt ſtratum conſiſts of tanner's bark about two inches thick. The bed is then to be covered with a little manure, and about three inches of good ſoil, and finally with a thick coat of ſtraw. The ſhed behind moſt hot-houſes is found to afford a convenient place for a muſhroom bed; as no light is required, but only warmth, and occaſional moiſture. See Kenedy on Gardening, Vol. II. for a particular account of this proceſs.

In the tanyards of Derby, I am well informed, that a production of muſhroom ſpawn always occurs in the path, where the horſe walks, which draws the rolling ſtone to grind the bark, which path conſiſts of powdered oak-bark and horſe-dung trampled together. Of this I was in one inſtance an eye-witneſs, but whether the embryons of muſhrooms were derived from the oak-bark or horſe-dung was not eaſy to determine.

Mr. Ferber, in his Travels through Italy, tranſlated by Raſpe, mentions the muſhroom-ſtone. He ſays "the pietra fungaia is a white calcareous ſtalactite, or tuph-ſtone, dug in the limeſtone hills bordering on Romagna, and endowed with the quality to produce in any ſeaſon of the year eſculent muſhrooms, if kept in a moiſt cellar, and now and then ſprinkled with water. This quality is owing to a great many roots, or vegetable fibres, together with the muſhroom ſeeds encloſed in its ſubſtance. They are uſed in ſome great houſes in Naples and Rome. I ſaw an indurated mould from the ſame place

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that had the fame quality, which was ufed by Mr. Fabriani in the mint of Florence."

From this account the mufhroom-ftone appears to confift of a porous tupha, like that with which the houfes are built at Matlock Bath; and which has been depofited from the water. But a later writer has fince analyfed one of thefe ftones, but does not mention how long it had been ufed for the vegetation of mufhrooms, which might in great meafure affect the refults of his analyfis. Mr. Gadd, in the Stockholm Tranfactions, fays, that this pietra fungaia defcribed firft by Ferber confifts of forty-five or forty-fix hundredth parts of filiceous earth, and twenty of a calx of iron, with a little magnefia and vegetable alkali. Analytic. Review, Dec. 1798.

In this country the cellars would not be fufficiently warm to produce mufhrooms at any feafon of the year; but as this mufhroom-ftone is of calcareous origin according to Ferber, it fhews, that calcareous earth is friendly to the growth of mufhrooms; and a fimilar porous ftone from the vicinity of Matlock Bath might probably be permeated in a fimilar manner with the roots of them, as a convenient repofitory of them to be raifed into life occafionally by warmth and moifture.

Some of the fungi are believed to poffefs an intoxicating quality, and are eaten for that purpofe by the peafants in Siberia. One fungus of the fpecies agaricus mufcarum eaten raw, or a decoction of three of them, produces intoxication for twelve or fixteen hours. Hift. of Ruffia, Vol. I. Nichols, 1780. The Oftiachs alfo blifter the fkin by a fungus found on birch-trees, and ufe the officinal agaric for foap. Other fungi poffefs a juice fo acrid in their raw ftate as immediately to blifter the tongue, as I once experienced on tafting a minute drop of the juice of a large mufhroom, which on breaking the hat poured out a yellow juice, which became purple or blue in a few feconds of time on its being expofed to the air; which I believed to be the fungus deliciofus of Linneus; the acrimony of which might neverthelefs probably be deftroyed by a boiling heat. And it is alfo probable, that the common efculent mufhroom may fometimes difagree from their being not fufficiently ftewed, or by the incautious mixture of fome intoxicating fungi along with them.

Otherwife thofe in common ufe at our tables appear to fupply a wholefome and nutritive food, approaching towards an animal nature. Two or three kinds are faid to be eaten in France befides the red-gilled ones which are eaten here; and it is probable many other kinds of fungi might be found agreeable to the palate, and wholefome food, if well boiled, which might deftroy their acrimony; and efpecially thofe which when broken have fimply the agreeable fmell of the red-gilled ones in common ufe; and fome of thefe, I fuppofe, might be eaten raw without injury, as many people eat the red gilled ones.

Befides fome mufhrooms with white gills, which when broken had the grateful fcent of the common red-gilled mufhroom, and which were faid to be more delicious, I have known the peziza auricula, or ear-fungus, which was formerly an article of the materia medica under the name of Jew's ear, to be ftewed and eaten in confiderable quantity with impunity; and was efteemed an agreeable article at the fupper-table. And as this was efteemed a pernicious genus of fungi by Clufins, it is probable, that many other fungufes might lofe their acrimony by the heat of ftewing, and become wholefome and agreeable food; which are at prefent in difufe from their difagreeable acrimony in their raw ftate, or from the bad character they have accidentally acquired.

It fhould be added, that though thofe plants, which are fuppofed to poffefs an alkalefcent property, and to be liable to putrefaction fooner than other vegetables, lofe a part of their acrimony by a boiling heat, as water-creffes, cabbages, onions; yet that plants, whofe acrimony is of a different kind, as ginger, capficum, arum, do not become much milder by boiling. I this morning directed fome leaves

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of common ſpotted arum, and of arum ariſſarum to be boiled, and on taſting them found my tongue and lips almoſt excoriated. The nature of this kind of acrimony has not been ſufficiently inveſtigated by the chemiſts, but probably depends on a fixed eſſential oil.

III. *Barks.*

1. The barks of the trunks of trees are ſimilar to thoſe of their roots, and may be eſteemed a part of them, as they conſiſt of an intertexture of the veſſels, which deſcend from the plume of each individual bud to the radicle of it, and conſtitute its caudex. The bark nevertheleſs of the root is furniſhed with lymphatics to abſorb water and nutritious juices from the earth, and is covered with a moiſter cuticle; while the bark of the ſtem is furniſhed with lymphatics to abſorb moiſture from the air, and is covered with a drier cuticle; the latter reſembling the external ſkin of animals, and the lymphatics, which open upon it; and the former reſembling the mucous membrane of the ſtomach, and its lacteals.

As the ſap-juice riſes in all deciduous trees during the vernal months to expand their foliage, though probably in greater quantity in ſome trees than in others, it muſt conſiſt not only of ſugar and mucilage, as in the maple and birch, but of various other ingredients in different trees, which have not been attended to; as appears from the taſte of their young leaves, as of oak or aſh. And as ſome of theſe materials reſide in the roots and ſap-wood or alburnum, ſo others of them may perhaps reſide in the bark, where they have been depoſited during the preceding ſummer, and become lignified by the warmth of the ſpring, or diſſolved by the moiſture abſorbed from the earth and air, and conveyed upwards to the opening buds; whence it is evident, that the barks of trees ſhould be taken off for uſe in winter or in early ſpring, before their buds begin to expand; as then a part of theſe nutritious juices, or of the other materials, which are required for medicines, or in the arts of dying and tanning, are in part expended on the young leaves; which generally poffefs the tafte and qualities of the bark, though in a lefs degree.

It may neverthelefs be obferved, that all thefe aftringent, or other materials, may refide in the alburnum of the trunk or roots of all perennial vegetables, as well as in their barks; becaufe the young leaves, which pullulate on decorticated oaks, have the fame bitter flavour as the leaves on thofe, which have not been decorticated; which may in part be derived from the bark of the root, which is ftill in the ground, and be carried up the veffels of the fap-wood to the new buds.

2. Hence the bark of oak-trees fhould be taken off during the winter; but when the fap-juice refiding or afcending in the veffels of the alburnum becomes more liquefied by the warmth of the fpring, or is mixed with more moifture, and pufhed up with great force by the abforbent veffels of the roots, it oozes out in fome degree between the alburnum and the bark; and thus the bark becomes fo much more readily feparated from the fap-wood; whence this bufinefs is generally done early in the fpring, and fhould be performed as foon as this facility of detracting the bark appears, as mentioned in Sect. III. 5; becaufe this procefs of the germination of the buds continues to injure the bark, whether the tree be cut down or not; as the buds expand their foliage on new felled trees, as they lie on the ground.

3. The interior barks of fome trees, like the alburnum or roots above defcribed, contain much mucilaginous or nutritious matter; as the bark of elm, ulmus, and of holly, ilex; and probably of all thofe trees or fhrubs which are armed with thorns or prickles, which are defigned to prevent the depredations of animals on them, as the hawthorn, goofeberry, and gorfe, cretægus, ribes groffularia, ulex. The internal barks of thefe vegetables may be conceived to be their alburnum lefs indurated, and might probably all be ufed as food for ourfelves or other animals in years of fcarcity, or for the purpofe of fermentation; as I doubt not but the inner bark of elm-trees, ul-

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mus, detracted in the fpring by being boiled in water might be converted by the addition of yeft into fmall beer, as well as the alburnum of the maple and birch, acer et betula; all which are now fuffered to be eaten by infects when thofe trees are felled.

For the fugar, which is extracted from the vernal fap-juice of the maple and birch, as well as that found in the manna-afh, fraxinus ornus, feems to refide during the winter months in the root or alburnum, rather than in the bark properly fo called; and to become liquefied, as above mentioned, by the warmth of the fpring, or diffolved by the moifture abforbed from the earth, and conveyed to the opening buds; but refides folely in the roots of perennial herbaceous plants; and in the economy of graffes, and I fuppofe of the fugar-cane, it is depofited at the bottom of each joint, which is properly the root of the ftem above it, as fhewn in Sect. IX. 3. 1.

Of thefe the bark of the holly not only yields a nutritious mucilage, and thus fupplies much provender to the deer and cattle in Needwood-foreft by the branches being cut off, and ftrewed upon the ground, in fevere feafons of froft and fnow; but contains a refinous material, which is obtained by boiling the bark, and wafhing away the other parts of it. This refinous material poffeffes a great adhefivenefs to feathers and other dry porous bodies, and has hence obtained the name of bird-lime, and much refembles the caoutchouc or elaftic refin brought from South America, and alfo refembles a foffil elaftic bitumen found near Matlock in Derbyfhire, both in its elafticity and inflammability. Hollies may be worth cultivating for this material befides the ufes of their wood, as I was informed, that thirty years ago a perfon, who purchafed a wood in Yorkfhire, fold to a Dutch merchant the bird-lime prepared from the bark of the numerous hollies for nearly the whole fum given for the wood; which if it could be hardened might probably be fold for the elaftic refin above mentioned. Whether this refembles the nutritive refinous material

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found in wheat flour, when the mucilage and ſtarch are waſhed from it, might be worth inquiry, as mentioned in Sect. VI. 8. 5.

4. Other barks contain bitter, reſinous, aromatic, or acrid materials, which ſupply the ſhops of medicine, as peruvian bark, caſcarilla, cinnamon, and were deſigned by nature to protect thoſe vegetables from the depredations of quadrupeds or inſects. Hence many trees, and even the wood of them, after it is dried, and made into domeſtic furniture, is never devoured by worms, as the mahogany, cedar, cypreſs; and hence many plants, as the foxglove, digitalis, houndstongue, cynogloſſum, henbane, hyoſciamus, and many trees, are not devoured by any animals; as their juices would be poiſonous to them, or much diſagree with their ſtomachs, if their diſguſtful flavours to the noſe or palate did not prevent their eating them. The ſame defence of the vegetable kingdom from human digeſtion, except thoſe which have in long proceſs of time been ſelected and cultivated, appears from the relation of ſome unfortunate ſhipwrecked travellers, who have paſſed ſome hundred of miles along uninhabited countries almoſt without finding an eſculent vegetable production.

5. Other barks contain reſtringent or colouring particles, employed in the arts of dying and tanning, as berberry, oak, and aſh, berberries, quercus, fraxinus. The art of tanning conſiſts in filling the pores of the animal mucous membrane with theſe reſtringent particles found in ſome vegetables, which are believed to poſſeſs a quality of ſhortening animal fibres. Thus when a long hair is immerſed ſome time in a ſolution of the bark of oak, or of the galls produced on its leaves by the punctures of inſects, the hair is ſaid to be ſhortened. Whether this proceſs be occaſioned by chemical coagulation of the mucus, of which theſe fibres totally or in part conſiſt, or by capillary attraction tending to diſtend theſe fibres in breadth, and thus to ſhorten them, as a twiſted ſtring is ſhortened by moiſture, has not yet been well inveſtigated. By thus impregnating the pores of animal ſkins with vegetable particles, they become leſs

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liable to putrefaction, as confifting of a mixture of animal and vegetable matter, as well as much better adapted to many domeftic or mechanical purpofes.

The art of dying confifts likewife in impregnating the pores of dry fubftances with a folution of the colouring matter extracted from vegetables by the capillary attraction of thofe pores to the coloured folution. And fecondly, by a chemical change of thofe colouring particles after they have been imbibed, and the water of the folution exhaled, by again fteeping them in another folution, which may chemically affect the former. Thus as green confifts of a mixture of blue and yellow, it may be beft produced by boiling the material defigned to be dyed firft in a decoction of one of thefe colours, as of indigo; and then in that of another, as of the bark of berberry. And as a folution of iron becomes black when mixed with a decoction of oak-galls, by being in part precipitated; it is probable, that the particles of this combination of a folution of iron with reftringent matter may be larger than either of thofe particles feparately; and therefore that, if a dry porous fubftance be immerfed firft in a decoction of oak-galls, and after being fuffered to dry, is then immerfed in a folution of iron, the black tinge will penetrate into minuter pores, and thus become more intenfe, than if the fubftance had been immerfed in the black dye already prepared.

6. Other barks are ufed for apparel, paper, cordage, and for many mechanical purpofes, owing to the ftrength and tenacity of their fibres, or to the finenefs of them; as hemp, cannabis; flax, linum; for the purpofes of fpinning and weaving; an art invented by Ifis, queen of Egypt, who feems firft to have cultivated flax; which was brought into Europe from the banks of the Nile. The bark or leaves of the papyrus, a flag of the Nile, was firft ufed for paper; and the bark of the mulberry-tree is ftill made into cloth at Otaheite and other fouthern iflands.

The art of feparating the fibres of the bark of plants, as they con-

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ſiſt of the caudexes of buds, or the connecting veſſels between the plumules and the radicles of them, is performed by ſoaking them ſome weeks in ſtagnant water; till the mucous membranes, which connect theſe fibres, are deſtroyed by putrefaction; and afterwards by drying them, and beating off with hammers, what may ſtill adhere.

Theſe fibrous parts of the barks of trees, as they contain no ſaccharine matter, like the alburnum, are much leſs liable to decay than the ſap-wood, or perhaps than any part of the timber. Maupertuis, who went to Lapland to meaſure a degree of the meridian, ſays, that among the numerous trees which lay upon the ground deſtroyed by age, or blown down by the winds, many birch trees appeared whole, owing to the undecayed ſtate of their bark; but crumbled into powder on being trod upon; and that the Swedes took the practice from this of covering their houſes with this unperiſhable bark, on which they ſometimes lay ſoil, and thus poſſeſs aerial gardens. Voyages by Mavor, Vol. XII.

7. To increaſe the quantity of bark it muſt be remembered, that the leaf-buds, or viviparous offspring of trees, as they form new buds, acquire new caudexes extending down into the ground, and thus increaſe the bark of the ſtem in thickneſs; but the flower buds acquire no new caudexes, but die, as ſoon as they have ripened their ſeed, and conſequently do not increaſe the thickneſs of the bark. Whence one method of increaſing the quantity of the bark is to increaſe the number or vigour of the leaf-buds in contradiſtinction to the flower-buds, which may be done by pinching off the flowers as ſoon as they appear; and as the bark becomes gradually changed into wood, this may be one method alſo of forwarding the growth of timber trees, as mentioned in the next Section.

8. The method of preſerving the bark of trees from moſs conſiſts in rubbing off that paraſite vegetable in wet weather by means of a hardiſh bruſh; which is ſaid to be uſed with advantage on the apple-trees in the cyder countries; and may at the ſame time give motion

to

to the vegetable circulation, or forward the afcent of their juices abforbed by the radical or cortical abforbents. In dry weather the brufh fhould be frequently dipped in water. Wafhing the barks of wall-trees by a water-engine may alfo facilitate the protrufion of their buds in dry feafons; and might poffibly prevent the canker, if applied to dwarf or afpallier apple trees. Other parafite vegetables muft be occafionally deftroyed, where they occur, as the lichens, fungi, miflletoes; with the ivies and other climbers, as fome kinds of lonicera, clematis, and fumaria, woodbine, virgin's bower, and fumitory.

9. When a wound is made in the bark fo as to expofe the alburnum to the air, the upper lip of the wound is liable to grow fafter downwards, than the lower one is to grow upwards, owing to the former being fupplied directly with nutritive juices fecreted from the vegetable blood, after its ventilation, and confequent oxygenation in the leaves; whereas the lower lip only receives thofe juices laterally by inofculation of veffels. Over thefe wounds the cuticle is liable to project, and to fupply a convenient hiding place for infects, which either eat the new fibres of the growing bark, and perforate the alburnum; or by their moifture, their warmth, and their excrements, contribute to the decay of the alburnum, and prevent the healing of the wound. Thefe dead edges of the projecting bark or cuticle fhould be nicely cut off, but not fo as to wound the living bark.

Plafters of lime, or of tar with fublimate of mercury, have been recommended to preferve the wounded parts from the air, and from moifture, and from infects; but as all thefe materials are injurious to the fibres of the living bark, they fhould be ufed with caution, fo as not to touch the edges of the wound, but only to cover the alburnum; for this purpofe white lead and boiled oil, mixed into a thick paint, or with the addition of fublimate of mercury, or of arfenic, or of fpirit of turpentine, may probably anfwer the purpofe; and may be of real utility on the wounds of thofe trees, whofe wood contains lefs acrimony, and is therefore more liable to be bored into and eaten by a large worm or maggot almoft as thick as a goofe-quill: which I have feen happen to a pear-tree, fo as to confume the whole internal wood, till the tree was blown down.

In refpect to the caution neceffary to be obferved in not touching the living edges of the wounded bark with fuch materials as may injure the tree by their abforption, I remember feeing feveral young elm trees, which died by their boles having been covered, as I was informed, by quick-lime mixed with cow dung to prevent their being injured by horfes; and I have feen branches of peach and nectarine trees deftroyed by fprinkling them, when in leaf, with a flight folution of arfenic, and others with fpirit of turpentine.

10. A more curious method of cure is faid to have fucceeded, where the bark of a tree has recently been torn off even to great extent, and that is by binding the fame piece of bark on again, or another piece from the fame tree, or from one of a fimilar nature, nicely adapting the edges of the bark to be applied to the edges of that, which furrounds the wound of the tree, which it is faid will coalefce in the fame manner, as the veffels of the bark of an ingrafted fcion unite with thofe of the bark of the ftock ingrafted on; which is ftrictly analogous to the union of inflamed or wounded parts of animal bodies, as in the cure of the hare-lip, or the infertion of the living tooth from one perfon into the jaw of another, or the factitious nofes of Talicotius.

If the bark over the cankered parts of apple-trees could be thus renewed by paring the edges of the mortified bark to the quick, and then nicely applying a piece of healthy bark from an apple-tree of inferior value, and fecuring it with an elaftic bandage, as a fhred of flannel, it would be a very valuable difcovery.

Another method, where a branch of a valuable tree is in the progrefs of being deftroyed by canker, might be by inclofing the cankered part, and fome inches above it, in a garden-pot of earth previoufly

vioufly divided, and fupported by ftakes, and tied together round the branch; which might then ftrike roots in the earth of the garden-pot, and after fome months might be cut off, and planted on the ground, and might thus be preferved, and produce a new tree; which experiment I have this fummer tried on two apple-trees, and believe it will fucceed.

SECT. XVIII.

PRODUCTION OF LEAVES AND WOOD.

I. 1. Leaves *are the lungs of vegetables. Grasses propagated by their roots. Some are viviparous. Joints of grasses are successive vegetables. And their roots. Extract roots of twitch-grass by a scarifier with inclined teeth. Produce root-leaves for grazing, and stem-leaves for hay. Eat down the first stem. Cut grass young for hay. Why young hay is liable to take fire. How to prevent it by straw. Eat low meadows late. Sow rye-grass, trefoil, white clover, for successive herbage. Other grass seeds. Roll them in spring. Effects of frost. Use more water as in rice grounds. Sow thick. Heavy cattle should be stall-fed. How to destroy tussocks. How to make hay.* 2. *Some root-leaves eaten raw. Others previously boiled. Upper part of some roots and of some stems esculent. Asparagus. Art of cultivation of root-leaves and stem-leaves. Of mulberry-leaves.* 3. *Etiolation of leaves lessens their acrimony. Etiolated flowers. Etiolated ladies.* 4. *Aromatic and bitterish leaves used as tea, as of sage. When to be gathered. Tea recommended.* 5. *Leaves used in medicine. Bog-bean instead of hops. Others for tanning, as oak, ash, and alder leaves. Others for dying, as indigo and woad.* 6. *Leaves will ferment and may make a kind of beer.* II. 1. Wood *is produced from leaf-buds. To increase wood moisten the trees. Scratch the bark. How to straighten crooked trees. Pinch off the flowers.* 2. *To render timber trees tall without knots, or crooked for ship-timber. Willows. Oziers. Sugar-maple. Scotch firs.* 3. *Preserve wood from lightning, and from wood-peckers.* 4. *Woods differ in colour. Used in dying. Differ in medical and chemical properties.* 5. *Oak corrodes lead. Sap-wood rots under lead. How prevented. Whence the mysteries of Free Masonry.* 6. *Woods differ in their hardness and smoothness. Blocks for printing.* 7. *In their durability as cypress. Alder for piles.* 8. *In lateral cohesion. Hygrometer. Pendulum.* 9. *In specific gravity. Rafts of hollow trunks.* 10. *In elasticity. Bows.* 11. *How to transplant large trees. How to* *to prop them. 12. Time of felling timber after barking it. The concentric rings of timber. 13. Pith is brain. Does not communicate from bud to bud. Sagoe from artichoke. From elder. 14. Boundary to the growth of trees. Not to coralline rocks.*

I. *Of Leaves.*

1. The buds of plants have already been ſhewn to be individual vegetable beings, and the leaves to conſtitute the lungs of each individual bud. And laſtly, that the new bud in the boſom of each leaf is the offspring from the caudex of that old bud, of which the leaf conſtitutes the lungs.

The leaves of graſſes are of great conſequence, as they nouriſh many of our domeſtic quadrupeds; the cultivation of graſſes has therefore been much attended to. Many of theſe propagate themſelves more by their roots than by their ſeed; eſpecially where their ſtems are perpetually deſtroyed by the grazing of cattle, ſheep, or geeſe; and ſome of them are ſaid to be viviparous, as the feſtuca dumetorum, or feſcue graſs; that is, that they bear bulbs on their ſtems after flowering inſtead of ſeeds, which in time drop off, and ſtrike root into the ground, like the polygonum viviparum, and the allium magicum; which circumſtance is ſaid to obtain in many alpine graſſes, whoſe ſeeds are annually devoured by ſmall birds.

The ſtems of the graſſes conſiſt in general of joint above joint without lateral branches; each joint of which ſeems to be a ſucceſſive plant growing on the preceding one, and generated in the boſom of the leaf, which ſurrounds it; the ſtem may therefore be eſteemed a ſucceſſion of leaf-buds, till at length a flower-bud is produced on the ſummit, as ſhewn in Sect. IX. 3. 1. In ſome graſſes, as the agroſtis canina, or triticum repens, dog's-graſs, twitch-graſs, or couch-graſs, the root conſiſts of joints as well as the ſtem; which may be conſidered as ſeparate individual plants, like the bulbs of potatoes, as every joint of theſe roots will grow into a new plant to the great

great annoyance of the agricultor, which, when the ground is not hard, may be beſt, I believe, drawn out by a deep harrow, or by Mr. Cook's ſcarifier; as a plough turns them over under the ſoil, as it breaks them, and thus much increaſes their number by in a manner tranſplanting them. The teeth of the harrow, or ſcarifier, ſhould be inclined forwards towards the horſe for the purpoſe of lifting up the roots, and that it may not too eaſily riſe out of the ſoil; and it ſhould be fixed by wedges or ſcrew-nuts to the wooden frame for the purpoſe of occaſionally lengthening them to adapt them to different ſoils, as the roots pierce deeper into leſs tenacious ſoils than into clayey ones.

Hence it appears, that a plant of graſs conſiſts not only of a tuft of leaves ſurrounding the root, but that the three or four lower joints of the ſtem, as of a wheat-ſtraw, are ſo many ſucceſſive leaf-buds, which are generated by the caudex of the leaf, which ſurrounds each joint, and precede the flower-bud at the ſummit; and that hence with the deſign of producing much herbage for cattle, the propagation of new leaves from the root is principally to be attended to; but with the deſign of producing hay, or winter fodder, the leaf-buds of the ſtem are principally to be attended to.

For the former of theſe purpoſes the ſtem of graſs ſhould be eaten down as ſoon as it riſes; whence more graſs leaves will ariſe from the root; as is well known to thoſe who eat down the firſt ſtem of wheat, when it is too luxuriant. For the ſecond purpoſe the leaf-buds, which conſtitute the ſtems of graſs, ſhould be cut down, before the flower-ſtem at the ſummit has begun to ripen its ſeeds; as at that time the ſweet juice lodged in the joint below the flower-ſtem becomes expended on the ſeed; and the ſtem becomes converted into ſtraw rather than into hay.

From hence it is readily underſtood, why thoſe paſtures, which are perpetually grazed, are ſo much thicker or cloſer crowded with graſs roots than thoſe, which are annually mowed; and why graſs cut young makes ſo much ſweeter and more nutritive hay than that, which has ripened and ſhed its ſeed. And laſtly, why the hay from graſs cut young is ſo much more liable to take fire, if ricked too moiſt; becauſe the greater quantity of ſugar in the joints of the ſtems produces ſo violent a fermentation, when it has ſufficient water to diſſolve it, that it generates ſo much heat as to burſt into flame. This might beſt be prevented, where chopped ſtraw is deſigned to be given to horſes along with their hay, by laying alternately in the hay-ſtack a ſtratum of new hay and a ſtratum of ſtraw, or of clover and ſtraw; whence the rapid fermentation, which occaſions combuſtion, may be prevented, and the ſtraw may be rendered eaſier of digeſtion by being impregnated with the fermentative infection, or yeſt, of the fermenting hay.

The art of increaſing the quantity of leaves round the roots of graſſes conſiſts in eating off the central ſtems by ſheep, or horſes, or cattle, early in the ſeaſon, as above mentioned; whence new ones are produced around the firſt joint of the ſtem thus bitten off, and from the diſtant horizontal root-wires of ſuch graſſes, as produce them. In low meadows it is hence doubly profitable to eat down the early graſs till about the middle of May, as in moiſt ſituations there is no danger but a crop of hay will ſucceed; which by this method will be finer and more copious; and at the ſame time ſome weeks provender of hay will have been ſaved by the uſe of the early graſs.

On land intended for paſture, as for ſheep, many people adviſe to ſow three kinds of vegetables, which may in ſome meaſure ſucceed each other in their growth. Mr. Parkinſon ſows four buſhels of the ſeed of rye-graſs, lolium perenne, ten pounds of trefoil ſeed, trifolium pratenſe, and ten of white clover, trifolium repens, on every acre; and adds, that the rye-graſs ſhould be eaten early, while the white clover is ſtill concealed in the ground, and the trefoil makes only ſome ſmall appearance. That when the rye-graſs is eaten down the

the trefoil ſprings up, and becomes food for the ſheep; after which the white clover ſucceeds; and after this is conſumed, the rye-graſs again ſprings up, and ſupplies food during the winter months, if the weather proves tolerably mild; and he further aſſerts, that a third more of ſheep at leaſt may be thus nouriſhed than by any other means. Experienced Farmer, Vol. I. p. 88.

For the production of a meadow much ſuperior to thoſe commonly ſeen Mr. Curtis recommends ſix kinds of graſs and two of clover to be ſowed; the ſeeds are to be mixed together in the following proportions. Meadow foxtail, alopecurus pratenſis, one pint; meadow feſcue, feſtuca pratenſis, one pint; ſmooth ſtalked meadow-graſs, poa pratenſis, half a pint; rough ſtalked meadow-graſs, poa trivialis, half a pint; creſted dog's-tail, cynoſurus criſtatus, a quarter of a pint; ſweet-ſcented vernal graſs, anthoxanthum odoratum, a quarter of a pint; Dutch clover, trifolium repens, half a pint; red clover, trifolium pratenſe, half a pint; theſe ſeeds are to be mixed together, and about three buſhels to be ſown on an acre in rows for the convenience of hoeing them. About the end of Auguſt or beginning of September they ſhould be occaſionally weeded and thinned, and rolled in the ſpring, to preſs down into the ground ſuch roots as may have been raiſed by the froſt.

Mr. Curtis thinks that meadow foxtail and rough ſtalked meadow-graſs ſuit moiſt ſoils the beſt; and that the ſmooth ſtalked meadow-graſs and creſted dog's-tail ſuit dry paſtures; and laſtly, that the meadow feſcue, and the ſweet-ſcented vernal graſs, ſuit land either moiſt or moderately dry; and gives the following order of their times of flowering. 1. Sweet-ſcented vernal. 2. Meadow foxtail. 3. Smooth ſtalked meadow-graſs. 4. Rough ſtalked meadow-graſs. 5. Meadow feſcue. 6. Creſted dog's-tail. See Hall's Encycloped. Art. Agriculture.

Not only new ſown graſſes deſigned for meadows, but the larger graſſes, which have the names of corn, as wheat, oats, barley, may be advantageouſly rolled, when dry, after froſt, which by expanding the

water

water in moiſt ſoils leſſens the cavities, which are occupied by roots; and as roots or their branches are in general conical, they become puſhed upwards; and ſuch as are looſe riſe quite out of the ground, as is often ſeen to happen to the roots of the ſtrawberries, when a froſty night has occurred ſoon after their being tranſplanted. After a ſlight froſt the larger pebbles of a gravel walk are ſeen below the ſurface, as if they had ſunk downwards during the night; whereas this is owing to a ſimilar cauſe, the expanſion of the moiſt ſoil or gravel an inch deep; but as the froſt had not penetrated ſo low as to ſwell the ground beneath the large pebbles, theſe had not been lifted up like the ſmaller ones, or the wet ſand.

Secondly, both to increaſe the quantity of leaves round the root, and to increaſe the ſize or vigour, as well perhaps as the number, of leaf-buds on the ſtem, a greater ſupply of water than uſual, where it can be done, would be advantageous; as is done to the rice-grounds in warm countries in the early part of its growth, and as in flooding our own meadows occaſionally in the vernal months. Thus very moiſt ſeaſons are well known to forward the luxuriant growth of the herbage, and ſtems, in the cultivation of wheat, and to render the ears later, and leſs prolific.

Where plants are ſown for the purpoſe of conſuming the firſt foliage, as graſſes or ſaint-foin, the ſeed ſhould be ſown thicker, than where the plant is grown for the purpoſe of producing ſeeds, as in wheat or peas; becauſe the quantity of the firſt foliage will be greater in reſpect to number; and the central parts of the tuſſocks, as is often ſeen in wheat and peas, when ſown too thick, will riſe two or three inches higher in their conteſt for light and air, like the trees of thick planted woods; and will hence produce a forwarder paſture as well as a more copious one.

To which ſhould be added, that the plants with ſucculent ſtems, as ſaint-foin, lucern, red clover, receive ſo much injury from the trampling of heavy cattle, that they ſhould be mowed, and given to cows and horſes in their ſtalls; which ſhould nevertheleſs have a yard or fold occaſionally to run into with the convenience of water; and if ſtraw be chopped along with this green food, it might be a cheap and a ſalutary addition.

Where a piece of graſs land is overrun with tuſſocks of ſour graſs, which often happens near towns, I have been informed, that lime or coal-aſhes ſpread on them would render the graſs ſweeter, ſo that horſes or cattle would eat it. But I ſuppoſe the more certain and advantageous management would conſiſt in mowing it frequently, and giving it to the horſes or cattle in the ſtable or ſtall; as I believe they will eat it greedily after it has been a few hours withered, and thus the land will not only yield more provender at preſent, but after a few mowings a ſweeter graſs will riſe in the place of that which was of a bad kind, or of too luxuriant growth; for which purpoſe it ſhould be mowed as near the ground as may be; or if it be frequently mowed during the ſummer, and left on the ground, ſome cattle will eat it, when it is withered to a certain degree; by which the diſagreeable flavour of it is probably leſſened or deſtroyed.

The art of making hay conſiſts in evaporating about two thirds of the weight of it, as obſerved by Young and Ruckert. Dr. Hales found a ſun-flower plant, which weighed forty-eight ounces to loſe thirty-ſix ounces by drying in the air during thirty days; and conſequently to have loſt three fourths of its weight. Vegetables to appearance perfectly dry contain three fifths or three fourths of their weight of water; a part of which water Mr. Kirwan thinks is not in its liquid ſtate, but that it is by a loſs of much of its ſpecific heat in a great meaſure ſolidified. Kirwan on Manures, p. 37. Thus when water is thrown on freſh quick-lime, a part of it unites with the lime, and becomes ſolid, giving out much heat; which converts another part of it into ſteam, as mentioned in Sect. X. 4. 4.

There are two methods of making hay practiſed in different parts

of

of the country. In the more fouthern counties the fwarths are not turned over or fcattered for a day, or two, or three, but remain as they were left by the fcythe. In the more northern counties the hay-makers follow the mowers, and fcatter the grafs immediately, or on the fucceeding day. Perhaps a method between thefe may in general better fuit this climate.

Herbs collected for medicinal purpofes, as well as flowers, fhould be dried in the fhade; otherwife they become bleached, and lofe both their colour and their odour, by too great infolation, and exhalation. Now if the fwarth of cut grafs be only turned over once a day for three or four days, the internal parts of it may be faid to be dried in the fhade; and afterwards if it be fpread over the ground for only a few hours on a fine day, I fuppofe it would become dry enough to ftack, and have loft confiderably lefs of its nutritive quality. Some advife a chimney to be left in the center of a ftack to prevent the hay taking fire, but there fhould then alfo be culverts under the ftack to fupply that chimney with air; which may be made by cutting three or four trenches in the earth, and covering them with boards or fticks with their apertures expofed to the wind in all directions. Perhaps the beft way would be to make the ftack narrow and long, and bent into a femicircle or crefcent to enable them the better to refift the winds, inftead of round or fquare, though a greater furface would indeed be afterwards expofed to the weather, and in fome degree injured, by this mode of conftruction.

When the grafs is fpread uniformly over the whole meadow, which is called *tedding*, it will fooner dry, as fo much larger a furface of it is expofed to the wind and fun; but it fhould certainly be put into fmall cocks or wind-rows at night, efpecially if the weather be moift; becaufe it will otherwife receive much dirt and flime from the innumerable worms, which rife out of the ground always in moift warm nights, and generally when the furface is covered with moift grafs at all feafons; and when they retreat into their fubterranean manfions in the morning, they are liable to draw in the ends of the grafs to ftop up the apertures of their holes, and by that means prevent the centipes from following them into their homes, and deftroying them. See Zoonomia, Vol. I. Sect. XVI. 16. Whence much of the new hay becomes injured by the foil, they previoufly pufh before them out of their mines, and by that which adheres to the grafs, which was drawn in to ftop the apertures of them, as well as by the flime, which they leave behind them on the new hay, which they pafs through or over.

On this account hay-cocks fhould be made as high as may be in proportion to their bafe, that lefs furface may be in contact with the ground, as well as that a greater furface may be expofed to the air for a quicker exhalation of its moifture, and for the purpofe of the better fecuring it from accidental fhowers.

In wet feafons, I fufpect, the beft method muft confift in turning over the rows of fwarth every day or every alternate day, or making it into fmall cocks, and turning them over in the fame manner, that the rain may not injure the whole of it by paffing perpetually through it, and wafhing away its faccharine and mucilaginous fluids; and alfo that the part next the ground, and the central parts of the cock or fwarth, may not pafs into fermentation and putrefaction. And laftly, when it can be put into tall cocks, as the weather becomes drier, it will not only fooner exhale its moifture by the contact of the atmofphere, but a beginning fermentation will fet at liberty fome degree of heat, and thus contribute to dry it by increafing the evaporation; as the great heat generated in hay-ftacks which have been finifhed but one day or two, affifts much to dry the whole ftack in moift feafons, as is feen by the denfe fteam, which arifes from them.

2. Many root-leaves are confumed at our tables either in their raw ftate, as thofe of water-crefs, fifymbrium nafturtium, lettuce, lactuca fativa, muftard, finapis, celery, apium; many others are previoufly

boiled

boiled to diminifh their acrimony, and to coagulate their mucilage, as the root-leaves of fpinach, fpinacia, of cabbage, braffica oleracea, and even of turnips, braffica rapa; along with thefe ftem-leaves of many plants the flower-buds at their fummits are eaten, as thofe of mercury, mercurialis, and of fome of the cabbage kind called brocoli, braffica italica.

Many of thefe leaves not only confift of a refpiratory organ, but at the lower parts of them efpecially, or in their ftalks, there exifts a refervoir of nutriment for the rifing flower-ftem or for the ripening feed, as in rhubarb leaves, and in cabbage leaves, which is fimilar to that in the roots of other herbaceous plants, and which renders them both palatable and nutritive. Moft of thefe concentric leaves are fituated in contact with the earth, as thofe of lettuces, lactuca, and falfafi, tragopogon. But others of them, as the cabbages, are placed on a ftem at fome diftance from the ground; in the former the upper part of the root or caudex is palatable and nutritious, as well as the lower part of the leaves; and fome of them are of fuperior flavour when boiled. In the latter the refervoir of nutriment for the future flower-ftem and feed confifts in the lower part of the ribs of the concentric foliage, as in the concentric leaves or lamina, which cover the bulb of the onion, or even in the ftalks, as in cabbages, and artichoke, which are therefore not only efculent, but palatable and nutritive.

Other leaves are eaten in their early ftate along with the ftem, which they furround, as afparagus, and the young fhoots of fpinach, and of fome kinds of brocoli, and of mercury; which laft are fometimes fuffered to fhew their flowers before they come to our tables, and are then treated of in Sect. XIX.

The art of cultivating all thefe confifts in fupplying them with abundant carbonic earth, and with abundant moifture, as thefe are more friendly to the luxuriant growth of root-leaves or ftem-leaves, than to the production of the flowers, or ripening of the feeds, as appears

pears by the too luxuriant growth both of herbaceous plants and of fruit trees in moiſt ſeaſons.

Another method of forwarding the growth of the new leaves and ſtem-ſhoots of perennial herbaceous plants, as of aſparagus, is annually to looſen or turn over the earth around and above the roots, for the purpoſe of admitting air into its cells or cavities to convert a part of the manure or carbonaceous ſoil, with which they have been ſupplied, into ammonia, or into carbonic acid, and thus both to afford them warmth and nutriment.

Add to this, that the leaves of trees may be increaſed in ſize by lopping off the branches, by which means the remaining buds acquire more nutriment; the black mulberry tree is thus kept low, and formed into extenſive ſhrubberies in China for the purpoſe of feeding ſilkworms, as obſerved by ſir G. Staunton, who thinks the leaves are thus rendered both larger and more ſucculent; and adds, that the aſh-tree is alſo ſometimes uſed for the ſame purpoſe.

3. Another method of deſtroying the too great acrimony of leaves, beſides that of boiling them, conſiſts in ſecluding them from light, and is termed etiolation. This is chiefly practiſed on cellery, apium, by earthing it up nearly to the top of the plant; and on ſea-kale, crambe maritima, by covering the plant entirely with horſe-litter or ſtraw, as deſcribed in Sect. XIV. 3. 3; and on lettuces, and endive, by tying together the root-leaves with a bandage.

In many plants the central bud during its early growth ſeems to be naturally in a ſtate of etiolation, as it is excluded from the light by the curvature of the ſurrounding foliage, as in cabbages, and particularly in ſome ſpecies of aloe, which are ſaid to conſume nearly a century in opening their numerous concentric foliage. Theſe etiolated leaves, like flowers before the calyx is opened, are white; and the leaves become green, or the flowers of many other colours, when expoſed to the light, as explained in Sect. XIII. 1. 3. It is probable that the foliage of many other plants might be rendered eſculent by thus deſtroying their acrimony, and decreaſing the tenacity of their fibres by etiolation, as well as the leaves of celery, apium ; and cardoon, cinara ; and of endive, cichorium endivia.

A ſecluſion from the ſun's light and from air has an effect ſomewhat ſimilar on animal bodies, rendering them pale and weak, as may be ſeen in the etiolated young ladies of ſome boarding ſchools ; and in thoſe who paſs their waking hours in unventilated parlours during more than half the night.

4. Other vegetable foliage has been brought into very extenſive uſe infuſed in hot water for its agreeable aromatic or bitteriſh flavour, as thoſe of foreign tea, thea ; and of the aſh, fraxinus, of our own iſland, the leaves of which were collected, before they became expanded, and ſold after being dried for the inferior kind of Bohea tea in ſo great quantity as to occaſion an act of parliament to be paſſed about forty years ago to lay a fine on any one, who ſhould have accumulated more than fifty pounds of aſh leaves, which were not the produce of his own trees. The leaves of many other of our domeſtic vegetables, as of mint, balm, and ſage, mentha, meliſſa, ſalvia, have been infuſed in hot water as an agreeable diluent beverage both in health and ſickneſs ; the laſt of which, the ſage, poſſeſſes a very pleaſant aromatic flavour ; and if the infuſion be poured from the leaves, before it has acquired too much of the bitter flavour, it is very grateful to the palate or ſtomach, and has been eſteemed ſalubrious from high antiquity to the preſent times, whence the line of Horace :

> Cur moriatur homo, cui ſalvia creſcit in horto ?

All theſe infuſions become nutritive, when drank with cream and ſugar, and have certainly contributed to the health of the inhabitants of this iſland by decreaſing the potation of fermented or ſpirituous liquors ; and to their morality by more frequently mixing the ladies and gentlemen in the ſame ſociety.

The leaves of theſe plants, as well as the aromatic or balſamic buds of ſome other plants, as of myrica, gale; of tacamahaca, populus balſamifera; of balm of Gilead, amyris giliadenſis, and many others, ſhould be gathered at the time of their greateſt fragrance, as the eſſential oils, which conſtitute their odorous exhalation, perpetually evaporate, as our ſenſe of ſmell informs us; and were apparently for the purpoſe of defending the plants from the depredation of inſects in their ſtate of infancy.

5. Other leaves have been uſed for medicinal purpoſes, and for the arts of dying and tanning, like the barks before mentioned; as the leaves of carduus benedictus, cnicus acarna, as an emetic; thoſe of foxglove, digitalis purpurea, as an abſorbent in anaſarca; thoſe of bog-bean, menyanthes trifoliata, as a corroborant; which laſt might probably ſupply the place of hops, humulus lupulus, in the breweries of malt-liquors; and as it might be plentifully cultivated on boggy grounds, which are not at preſent uſed for other purpoſes, might be a cheaper bitter to the conſumer, and ſave to the public much more fertile ſoil for the cultivation of corn or other valuable vegetables.

The leaves of teucrium ſcorodonia, wood-ſage, are as bitter as thoſe of menyanthes, bog-bean, and have been uſed with ſucceſs, as I have witneſſed, in the cure of agues; and, as it grows on dry barren ſoils, might poſſibly be cultivated to ſupply the place of peruvian bark in ſome diſeaſes, or to ſupply the uſe of hops in the breweries of malt-liquor.

The leaves of oak-trees, quercus robur, and of aſh-trees, fraxinus excelſior, and of alder, betula alnus, even after they drop ſpontaneouſly in the autumn, are ſaid to ſerve the purpoſe of tanning animal membranes, like the barks of the ſame trees ſpoken of in Sect. XVII. 3. 5; and for the purpoſes of dying, the leaves of indigo, indigofera tinctoria; and of wood, iſatis tinctoria; and of weld, reſeda luteola, have been much cultivated, and extenfively ufed; and a fpecies of polygonum is faid to be much cultivated in China for the fame purpofes as indigofera by fir G. Staunton; to which may be added the foliage of lichen fructicofus, or archil, a whitifh lichen brought from the rocks of the Canary Iflands, which gives a beautiful bloom to other colours, but is itfelf very fugitive. Linneus afferts in the Swedifh Tranfactions, that this archil mofs is to be found on the weftern coafts of England; and it is faid, that the archil is now prepared by Meffrs. Gordens at Leith near Edinburgh from a fpecies found in the Highlands of Scotland. Encyclopedia Britannica. Art. Archil. The manner of cultivation and of the extraction of the colouring matter from the leaves of thefe plants may be alfo feen in Bomare's Dictionaire Raifonne, and in Chambers's Encyclopedia. It it probable, that many other plants, as hedyfarum, faintfoin, or the broad thick leaves of phytolacca, might yield a fimilar material to that of indigo, woad, and weld, if properly cultivated and prepared, as well as other kinds of moffes or lichens to that above mentioned.

The green colour of perhaps all vegetables, as well as of thofe from which indigo and woad are produced, is owing to the blue fecula, which has been obtained for the dyers principally from thofe plants; and to a yellow material, which is more fugitive or more eafily decompofed, which yellow may poffibly be owing to iron. This blue fecula is fimply obtained from indigo, as it fubfides from the fluid, in which the plant is fuffered to ferment; and is obtained from woad along with the cellular parts of the leaves during their fermentation in water, and beaten into a mafs. It is probable that the blueft kinds of vegetables may contain the moft of this fecula.

For domeftic purpofes the juice of the fage-leaf, falvia officinalis, has been ufed both to give colour and flavour to cheefe; and the juice of fpinach is employed, I am informed, to colour the green ufquebaugh, a favourite dram with the Irifh vulgar. And it is probable, that the leaf of the vine, which bears purple grapes, might give a ſimilar colour and aſtringent taſte to our domeſtic wines, as the ſkin of the ſame grape gives to the foreign wines made from it; ſince the leaves of this vine always become quite red in autumn, before they fall, probably by the concentration of their acidity, as their water evaporates unſupplied; as all blue vegetable juices become green by an admixture of alkali, and red by that of an acid.

6. Another uſe for which leaves are collected by ſome gardeners, as they fall in autumn from any kinds of trees, is for the production of heat by fermentation in hot-houſes, or melon-frames, inſtead of oak-bark, after its bitter particles have been much extracted by the tanner; and it is probable, that many leaves might be ſelected, as they will thus undergo fermentation, which might afford a ſpirituous drink like ſmall beer without any diſagreeable flavour, or unwholeſome material; which now ſerve only for manure when gathered into heaps, or by their ſlow decay on arable lands; or encumber the graſs lands, they fall upon.

II. *Of Woods.*

1. The leaf-buds of trees producing a viviparous offspring acquire new caudexes, extending from the branches to the ground, and the intertexture of theſe caudexes forms the new bark over the old one. But the flower-buds acquire no new caudexes down the bark, as their oviparous progeny does not adhere to the ſide of the parent bud, but falls down when mature, and ſtrikes root into the ſoil.

Now as the bark of trees is thus produced along with the leaf-buds, and as it annually becomes alburnum or ſap-wood; and that ſap-wood gradually loſes all vegetable life, and becomes heart-wood, it follows, that the art of forwarding the growth of the wood of trees muſt conſiſt in producing and nouriſhing the leaf-buds.

For this purpoſe the roots of trees ſhould be ſupplied with rather more water, than they generally poſſeſs in their moſt natural ſtate, or the branches ſhould be ſprinkled by a water-engine; as moiſture facilitates

cilitates the production of the new caudexes of the leaf-buds probably by leſſening the coheſion of the cuticle, or mechanically relaxing it, like the cuticle of our hands when long ſoaked in water, as well as by ſupplying them with more nutriment.

It may ſometimes occur, that the cuticle of trees, or exterior bark, may adhere too ſtrongly, and by not opening in cracks confine the growth, or prevent the production of the caudexes of the new buds. There is annually a new cuticle produced beneath the old ones, as well as a new bark above the old ones; hence ſome trees have as many cuticles as they are years old, others caſt them more eaſily, as a ſnake caſts its cuticle. When a number of cuticles thus exiſt one over another, it is uſeful to ſcratch them longitudinally, which will admit the new bark beneath, conſiſting of the caudexes of the various buds to ſwell out, and form a line more prominent than the other parts of the trunk of the tree. If crooked young trees be thus ſcratched internally in reſpect to the curvature, and this repeatedly, I am informed, that they will gradually become ſtraight, by thus encouraging the growth within the curvature more than on its convex ſide.

Another method of increaſing the number and vigour of the leaf-buds, and in conſequence of enlarging the wood of a tree, conſiſts in pinching off the flowers, as ſoon as they appear; as the nouriſhment is thus ſupplied to the leaf-buds by the inoſculation of the veſſels of the bark, which otherwiſe would have been expended on the flowers, fruit, and ſeeds. The truth of this circumſtance is not only countenanced by gardeners, who pull off the flowers of fruit-trees lately planted to encourage their growth, but alſo from the appearance of ſickly trees; which are liable to periſh, when in flower. In this caſe it often happens, that, after the flowers fade, ſome of the leaf-buds continue to expand, or new ones put out, owing to the ſupply of nutriment not being now expended on the flowers.

2. As tall timber trees without branches, and conſequent knots in the timber, are moſt valuable except for ſhip-building; this may be

 certainly

certainly effected by planting them near each other; as then the powerful conteſt with each other for light and air propels them upwards, inſtead of producing many lateral branches; as may be ſeen in many woods, which have not been too much thinned. For this purpoſe ſome have planted trees of leſs value though of quicker growth, as pines, amongſt oaks; which may be pruned or lopped, if they ſhade the oaks too much, and may be finally removed, when the oaks are crowded by them; whence ſingle trees ſeldom grow ſo tall as thoſe in woods, and appear ſtunted, as it is called; which is generally aſcribed to the cold ſeaſons, or to their being expoſed more to the winds; which may perhaps ſometimes happen in this northern climate; or where trees are expoſed to inſalubrious air, as near the ſea; or exiſt in colder ſituations, as on the ſummits of mountains.

Something ſimilar to this may be ſeen in tuſſocks of graſs, or where too many ſeeds of wheat have been ſown near together. The central part of the knot of wheat or graſs grows much taller than the external part, ſo as to give it a conical figure; which has been by ſome aſcribed to the central part having been ſheltered from the cold by the external ring, but is more generally owing to the ſtruggle of the internal ſtems for the acquiſition of light and air.

The Society of Agriculture at Copenhagen has propoſed prizes concerning the cultivation of timber for ſhip-building. One queſtion is, whether the neceſſary form and degree of flexion can by any means be given to growing timber without injuring it? This I imagine may be done by annually ſcratching the external bark or cuticle either longitudinally or horizontally on the ſouth ſide of the part of a tree, which is wiſhed to be curved, as the ſouth ſide of trees are known to grow faſter annually than the north ſide, as is ſeen by the greater thickneſs of the concentric rings of a tree, when felled and ſawed into blocks; and becauſe the cuticle bounds the lateral growth of the trunks of trees, as the ſkin of animals bounds the growth of the

the cellular parts beneath it; and hence that fide of the tree, where the cuticle or exterior bark is frequently fcratched through, will become larger than the other fide of the tree, and tend to bend it into a curve with the fcratched fide outwards. Trees alfo on the outfide rows of woods will fpontaneoufly bend outwards for light and air, and may I fufpect be more eafily formed into proper curves by the method above propofed. And where trees in a wood are at a proper diftance from each other, they may forcibly be bent by cordage towards each other, and then by wounding the exterior and interior bark longitudinally, or perhaps horizontally alfo on the exterior fide of the curved part of the tree, they may be brought into almoft any degree of flexure, which they will afterwards preferve as the tree advances.

Some of the quicker growing trees may be more valuable to the planter than oaks, and fome in different foils are more valuable than others; as willow-trees in the hedge-rows in moift grounds are faid, if headed once in ten years, on an average to produce each of them one fhilling a year. Perhaps the ozier for bafket making may be ftill more advantageous in low grounds; there is a valuable paper on the planting of them and the choice of the kinds of them in the Tranfactions of the Society of Arts, Vol. XVI. p. 129, by Mr. Phillips. Perhaps the fugar-maple may alfo be cultivated in this climate to advantage on many barren commons, as on Cannock Heath. And certainly pines, as Scotch fir, might in thefe fituations fucceed aftonifhingly, as appears by the plantations of Mr. Anfon on the barren mountains near his feat in Staffordfhire; and alfo from the plantations of the marquis of Bath at the foot of Wiltfhire Downs near Warminfter, whofe fteward, Mr. Davis, has given a valuable account of the profit of planting Scotch fir in preference to other timber trees; and finally afferts, "that although fir-timber is worth individually more per tree than oak or beech of the fame fize, thefe trees will neverthelefs grow fafter and thicker together than any other trees. Four firs

firs will grow, where but one oak or beech will grow; for firs are the better, and deciduous trees the worfe, for being crowded." I fuppofe becaufe the branches of the latter are valuable, but the former is injured by the knots left in the trunk, where large branches have exifted. Tranf. of Society of Arts, Vol. XVI. p. 126.

Mr. Davis adds further, I fuppofe from his own obfervation, that "the chalk-hills in Hampfhire are peculiarly proper for beech; the flinty loams and clays of the fame county for oaks and afh; the moffy fteep fides of the Wiltfhire Downs for hazel; the rugged and almoft naked rocks of Mendip in Somerfetfhire near Chedder produce the lime-tree and the walnut in the greateft luxuriance; and on the higheft parts of the fame Mendip hills, where no other tree can ftand the fea-breeze, fycamore flourifhes as well as in the moft fertile vallies. But taking into confideration the general demand of countries, and the peculiarities of different foils, no kind of wood is fo generally profitable for planting in coppices as afh." *Ib.*

3. Another thing concerning timber-trees, which ought to be attended to, is the injury, they are liable to receive from lightning; which, I am informed, is much more frequent than is generally fuppofed; infomuch that in felling moft woods, efpecially thofe which grow in wet fituations, very many of the trees are found to be cracked longitudinally to the great injury of the timber; to prevent this, pointed wires, as thick as a goofe quill, fhould be attached to a few of the talleft trees of all flourifhing woods reaching above their fummits, as conductors of lightning. Add to this that the holes made by wood-peckers, I am told, are very numerous, and do much injury to the timber of our forefts, which can only be prevented by deftroying that beautiful and ingenious bird.

4. Woods differ from each other in many refpects, and are therefore ufed for many other purpofes befides mechanical ones; as in colour; whence particular woods are chofen for their beauty in the conftruction of the furniture of houfes, as rofe-wood, afpalathus;

others are ufed in the art of dying, as the Campechy wood, hæmatoxylum, and faunders, fantalum, and pterocarpus; and feveral others. Other woods differ in their medicinal properties, as guaicum, quaffia, Campechy wood, and faffafras. Others differ in their chemical properties, affording effential oils, as oleum rhodii, and turpentines or balfams, and tar; and in their reftringency, as the oak.

5. The oak probably contains much gallic acid, fuch as has been extracted from the galls occafioned on their leaves by the punctures of infects; whence oak boards are faid to corrode the fheets of lead, which are laid on them, and are hence believed to be improper for the gutture-boards on the roofs of houfes. But the fap-wood, or external part of all timber, I fufpect, muft be improper for this purpofe on another account; as, when confined from much air by the fheet of lead over it, it muft lie for many months in the year in that ftate of moifture, which will favour the fermentation of the faccharine matter, which all fap-wood contains; and will thence be fubject to the dry rot, as it is called by architects. This may be long prevented by leaving proper holes in the walls on all fides the building immediately under the roof, as has been generally done by thofe itinerant bodies of architects, who fhewed fuch prodigies of genius in the conftruction of cathedrals in this ifland, and all over Europe; and whofe fecret identifying words, and confederate figns, which were neceffary to them in foreign countries, whofe language they had not time to acquire, feems to have given origin to the modern myfteries of Free-mafonry.

The rot of wood might probably be entirely prevented by foaking dry timber firft in lime-water, till it has abforbed as much of it as may be; and then after it is dry by foaking it in a weak folution of vitriolic acid in water; which will unite with the lime already depofited in the pores of the timber, and convert it into gypfum; which I fuppofe will not only preferve it from decay for many centuries, if

it

it be kept dry, but alſo render it leſs inflammable, a circumſtance worthy attending to in the conſtruction of wood-built houſes. I alſo conceive that beams ſo impregnated would be leſs liable to ſwag, and boards ſo prepared leſs liable to warp. In the immenſe ſalt-mines of Hungary many large wooden props, which ſupport the roof, and are perpetually moiſtened with ſalt-water trickling down them, are ſaid to have ſuffered no decay for many centuries.

6. Woods alſo differ from each other in their hardneſs, or the general coheſion of their particles, whence one kind of timber has obtained the name of iron-wood, ſideroxylum. Others differ in the fineneſs of their conſtituent fibres, which ſhew a beautifully ſmooth poliſh, when planed, as roſe-wood, aſpalathus.

Where theſe two properties of hardneſs and ſmoothneſs exiſt together, as in box, buxus ſempervirens, the wood muſt be peculiarly valuable for the purpoſe of making wooden printing blocks, ſo well managed at this time by Mr. Bewick of Newcaſtle in his books of Natural Hiſtory of Quadrupeds and Birds.

7. Other woods differ in their durability, as cypreſs, cedar, mahogany, are ſaid to be indiſtructible by time, or by the depredation of inſects. The wood of the cedar of Bermudas, Juniperus Bermudiana, in which black-lead pencils are incloſed, is ſaid not to be eaten by either aerial, terreſtrial, or marine inſects, and is thence uſed in the Weſt Indies for building veſſels, whoſe bottoms are not penetrated by ſea-worms. The unperiſhable cheſts, which contain the Egyptian mummies, were of cypreſs, as well as the coffins in which the Athenians are ſaid by Thucydides to have buried their heroes. The gates at St. Peter's at Rome, which had laſted from the time of Conſtantine to that of Pope Eugene the fourth, that is eleven hundred years, were of cypreſs, and had at that time ſuffered no decay.

Of theſe ſome are believed to endure longer in water than others, as alder, betula alnus, and is therefore eſteemed preferable for piles to guard the banks of rivers. But Mr. Brindly, the conductor of the grand trunk canal, aſſured me, that he believed from obſervation, "that red Riga deal, or pine-wood, would endure as long as oak in all ſituations," owing perhaps to its being ſo full of reſin or turpentine.

8. Other woods differ in the degree of the lateral adheſion of their longitudinal fibres, as the fir-wood, or deal, pinus, whence the timber readily ſplits by wedges. As the moiſture of the atmoſphere is abſorbed into the pores of the dry cellular membrane, whch connects the longitudinal fibres of theſe woods, more than into thoſe of the longitudinal fibres themſelves, they become much more dilated laterally than extended longitudinally, by the change of a dry atmoſphere to a moiſt one; whence by joining pieces of deal cut croſs-wiſe into a rod of ſome feet in length, a very ſenſible creeping hygrometer was made by Mr. Edgeworth, deſcribed in the Botanic Garden, Vol. II. note on Impatiens. And as this wood is not liable to be much extended by low degrees of heat, when it is impregnated with boiling oil, or covered with varniſh, to prevent the acceſs of aerial moiſture, the pendulums of time-keepers have been conſtructed of it, which have not perceptibly lengthened in any variations of the heat or moiſture of the atmoſphere.

9. Another circumſtance of great conſequence, in which woods differ, is their ſpecific gravity, as many of them will ſink in water, as oak after it has been long moiſtened; and others will ſwim with much of their contents above water, as deal, and hence have been uſed for the conſtruction of rafts for the purpoſes of rude navigation; and which are now ſaid to be conſtructed in France as engines of war, probably for the deſign of ſuddenly landing troops, horſes, artillery, and proviſions, from the ſhips of invading armies on dangerous ſhores, and for the certainty of re-embarking them. Theſe nevertheleſs can not carry great burthens ſimply by their ſpecific levity; but if each piece of timber could be made hollow, and rendered water-tight, ſo as to contain air, which might probably be done by

boring them, and plugging up the ends ; or by joining thick boards together by means of paint and flannel, or caoutchouc, ſo as to conſtruct long ſquare wooden troughs filled with air, perhaps eight or ten inches diameter within, and twenty or thirty feet long. If the junctions of theſe could be rendered water-tight, and a number of ſuch hollow trunks could be chained looſely together, and laid croſs-wiſe three or four times over each other, they might carry very large burthens, not eaſily to be deſtroyed by ſtorms, or ſunk by cannon ſhot.

10. Another difference of the longitudinal fibres of timber conſiſts in their degree of elaſticity, a circumſtance of much greater conſequence to our anceſtors in reſpect to the art of war than to the preſent generation ; as their bows for dicharging arrows, and the catapulta, or engine for throwing ſtones, depended on the recoil of rods or beams of timber forcibly bent into a curve. For the conſtruction of bows the yew-tree, taxus, was uſed in this iſland, and was planted in church-yards, probably for the purpoſe of ſupplying the youth of the pariſh with bows, that they might become expert in the uſe of them ; many of which have acquired extreme old age, and remain to this day.

11. When tall trees are deſigned to be tranſplanted for the purpoſe of ornamenting a pleaſure-ground, it is proper to dig a circular trench round them two or three feet deep in the early ſpring ; whence many new roots will ſhoot from thoſe, which have their ends cut off, and thus the ball of earth will be better held together, when the tree is removed in the ſucceeding autumn, and the tree by having previouſly produced ſo many more fine abſorbent radicles will be more certain to grow in its new ſituation.

Hence when new grafted fruit-ſcions on young ſtocks are deſigned to remain a few years in the nurſery, before they are deſigned for ſale, ſome provident gardeners I am told tranſplant them every two years, that the root-fibres may be more numerous in a ſmall compaſs,

paſs, which occaſions them to grow, when finally tranſplanted, with more certainty, and with greater vigour.

As tranſplanted trees ſhould not be ſet too deep in the ground, as their growth is then always much checked, as explained in Sect. XV. 2. 4. they generally require ſome kind of props to prevent them from being overturned, or much ſhook by the winds, before they have ſufficiently extended their roots. As the bark is the only living part of the tree, it is liable to receive much injury from its contuſion by the preſſure of the props againſt it, or by the ſtrangulation of the bandage which holds it to them. Hence as the internal wood of a tree is not alive, I remember many years ago, that I faſtened one prop by a ſtrong nail to each fruit-tree of a ſmall orchard, which I then planted; and found the tree ſupported with much leſs apparent injury than in the uſual manner by three props and adapted cordage.

12. The time for felling timber has generally been in the winter ſeaſon, when labourers could beſt be ſpared from other rural employments, and from the architecture of towns; but it was long ago obſerved by Mr. S. Pepys in a paper publiſhed in the Philoſoph. Tranſact. Vol. XVII. p. 455, that the beſt time for felling oaks for ſhip-building was after having taken off the bark in the early ſpring, and having ſuffered the new foliage to put forth and die. For by the pullulation of the new buds the ſaccharine matter in the ſap-wood or alburnum is expended, and it then becomes nearly as hard and durable as the heart-wood, being both leſs liable to decay, or to be penetrated by inſects; which was a curious and ingenious diſcovery at that time, though the theory was not well underſtood; the truth of which has now been eſtabliſhed, I believe, by the experience of a century.

As the bark of trees annually changes into alburnum or ſap-wood, ſo the alburnum annually changes into lifeleſs wood; whence the concentric rings, which are ſeen in the trunks of trees, when they

3 X 2 are

are felled, are annually produced; and are ſaid generally to be thicker on that ſide of the trunk, which grows towards the ſouth, than on the northern ſide, and thicker in the ſummers moſt favourable to vegetation than the contrary. Theſe rings, as they loſe their vegetable life, and at the ſame time a part of their moiſture by evaporation, or abſorption, gradually become harder and of a darker colour; inſomuch, that by counting their number, it is ſaid, that not only the age of the tree, but that the mildneſs or moiſture of each ſummer during the time of its growth may be eſtimated by the reſpective thickneſs of the rings of timber.

13. In the ſame manner the central pith alſo loſes its vegetable life, probably after the firſt year; and then gradually becomes abſorbed, or ſo impregnated with ligneous particles, as not to be diſtinguiſhed from the ſurrounding wood. The pith of a young bud ſo reſembles the brain and ſpinal marrow of animals in reſpect to its central ſituation, that it probably gives out nerves to every living fibre of the bud; though theſe have yet eſcaped our eyes and glaſſes; and thus furniſhes the power of motion, as well as of ſenſation, to the various parts of the vegetable ſyſtem. One curious fact, which I have obſerved, ſeems to countenance this conjecture; which is, that the pith of a laſt year's twig communicates to the leaves on each ſide of it, but not to the new buds in the boſoms of thoſe leaves; becauſe thoſe new buds are each an individual being, generated by the caudex of the leaf, and muſt therefore poſſeſs a ſenſorium of its own. See Sect. I. 8. and IX. 2. 4.

The pith of trees contains much mucilage, as well as the ſtalks of annual and perennial plants, whether they are hollow or not; the pith of a palm-tree, cycas circinalis, is ſoftened with water, and paſſed through ſieves, and thus forms the ſagoe of our ſhops; it is poſſible the large pith of the ſtalks of artichokes, cinara ſcolymus, might be manufactured into a ſimilar kind of taſteleſs mucilage; and the pith of the young ſhoots of elder, ſambucus nigra, might alſo

poſſibly

poſſibly be made into taſteleſs mucilage, if previouſly agitated in cold water to waſh away any acrid material, as in the preparation of ſtarch.

14. When we contemplate the manner of the production of the internal wood of trees from the induration of the ſap-wood, and the annual increaſe of the ſap-wood from the bark, which was previouſly generated by the caudexes of the numerous buds; there would appear to be no natural boundary to the growth of trees. But that their trunks, though a mile diſtant from each other, might be enlarged, till they meet together, and cover the whole earth with ligneous mountains, conſtructed by ſucceſſive generations of vegetable buds; as ſome parts of the ocean are crowded with calcareous rocks, fabricated by the ſucceſſive generations of coralline inſects!

A very large tree is deſcribed by Mr. Adanſon in Africa, which is called by Linneus Adanſonia, in honour of that philoſopher; of which he ſays the diameter of the trunk frequently exceeds twenty-five feet, and the horizontal branches are from forty-five to fifty-five feet long, and ſo large, that each branch is equal to the largeſt tree in Europe. The breadth of the top is from 120 to 150 feet; and one of the roots bared only in part by the waſhing away of the earth by the river, near which it grew, meaſured 110 feet long, and yet theſe ſtupendous trees do not exceed 70 feet in height. Voyage to Senegal.

And in this country, when the internal wood is gradually detached from the alburnum, as it decays, as in ſome old hollow oaks and willows, ſo that it does not deſtroy the tree by the putrid matter being abſorbed, there ſeems to be no termination of the growth of the external remains of the tree, till the wind blows it down from its want of ſolid wood to ſupport it. Of this kind of hollow tree a remarkable inſtance remains in Welbeck Park in Nottinghamſhire, through the middle of which a coach is ſaid to have been driven. There is another oak of uncommon dimenſions in the foreſt of Needwood,

 called

called Swilcar oak, celebrated in an unpublifhed poem by Mr. Mundy, on his leaving that foreft, and is there faid to be 600 years old.

But the caudexes of buds, which compofe the barks and afterwards the timber of trees, differ from the nefts or cells of the coralline infects, which compofe their calcareous rocks beneath the waves, in this circumftance. The cells of the coralline infects, like the fhells of other fea-animals, become harder by time, changing by flow degrees the phofphoric acid, which they contain, for carbonic acid ; and fome of them afterwards for filiceous acid, and are thus converted into limeftone and flint, and remain eternal monuments of departed animal life.

Whilft the remaining vafcular fyftem, after the death of vegetable buds, like the flefh of animals, undergoes in procefs of time a chemical decompofition, and lofes by fermentation and putrefaction both their carbonic and phofphoric acids, which probably gave them their folidity, and crumble into duft ; which is feen in the rotten trunks of trees, which lofe fo much of their carbon as they decay ; and alfo become luminous, when expofed to the air by the efcape or production of phofphoric acid. And finally, their other component parts are feparated by elutriation, and form moraffes ; whence coals, iron, clay, and fandftone ; all which are found on the lime-rocks, which were previoufly generated in the ocean, and remain eternal monuments of departed vegetable life. Whence it appears, that a boundary is fet to the fize of trees by their internal decay, but none to the growth of coral-rocks, which are fo formidable in the navigation of the fouthern ocean.

15. *Queftion on the cultivation of Timber.*

The political advantage or difadvantage of cultivating timber in this ifland fhould be here confidered. In the prefent infane ftate of human

human ſociety, when war and its preparations employ the ingenuity and labour of almoſt all nations; and mankind deſtroy or enſlave each other with as little mercy, as they deſtroy and enſlave the beſtial world; and may in time, for what appears to the contrary, return to their ſavage ſtate, and begin to eat each other again, as ſeems to have occurred at or before the commencement of almoſt all civil ſocieties; the firſt political attention ſhould certainly in this period of human infatuation be employed to ſtrengthen the country, to enable it to repel the invaſion of foreign enemies, and to defend its natural rights, when they are infringed by them; but not to attack or invade other nations for any predatory or ambitious purpoſe. The next important thing ſhould be for this nation to ſet a great example of juſtice and humanity to all contending nations, and thence again to introduce truth and virtue into the world with peace and happineſs in their train.

Now as the power to reſiſt invaſion, and to defend our natural rights, when infringed by foreign enemies, muſt depend more on the number of men than on the number of trees; there need be no heſitation in determining, that thoſe lands, which can be employed in the preſent production of vegetable or animal food, ſhould not be occupied in the tedious cultivation of future timber.

But that, as the ſummits of this country conſiſt principally of a ridge of mountains extending from ſouth to north between the eaſtern and weſtern ſeas, as thoſe of the Peak of Derbyſhire and the Moorlands of Staffordſhire, which are ſo bleak or ſo barren as to be totally unfit for the plough or for paſturage, and yet might be employed for raiſing variety of timbers; which from our great ſucceſſes in naval engagements may be termed with great propriety, when employed in building ſhips, the wooden walls of this iſland: All thoſe unfertile mountains from the extremity of Cornwall to the extremity of Scotland, ſhould be covered with extenſive foreſts of

ſuch

ſuch kinds of wood, as experience has ſhewn them to be capable to ſuſtain, and which may be beſt adapted to the conſtruction of ſhips.

16. The following addreſs to Swilcar oak in Needwood foreſt, a very tall tree, which meaſures thirteen yards round at its baſe, and eleven yards round at four feet from the ground, and is believed to be ſix hundred years old, was written at the end of Mr. Mundy's poem on leaving that foreſt, and may amuſe the weary reader, aud conclude this Section.

ADDRESS TO SWILCAR OAK.

Gigantic Oak! whoſe wrinkled form hath ſtood,
Age after age, the Patriarch of the wood!—
Thou, who haſt ſeen a thouſand ſprings unfold
Their ravel'd buds, and dip their flowers in gold;
Ten thouſand times yon moon relight her horn,
And that bright ſtar of evening gild the morn!—
Erſt, when the Druid-bards with ſilver hair
Pour'd round thy trunk the melody of prayer;
When chiefs and heroes join'd the kneeling throng,
And choral virgins trill'd the adoring ſong;
While harps reſponſive rung amid the glade,
And holy echoes thrill'd thy vaulted ſhade;
Say, did ſuch dulcet notes arreſt thy gales,
As Mundy pours along the liſtening vales?
Gigantic Oak!—thy hoary head ſublime
Erewhile muſt periſh in the wrecks of time;
Should round thy brow innocuous lightnings ſhoot,
And to fierce whirlwinds ſhake thy ſteadfaſt root;
Yet ſhalt Thou fall!—thy leafy treſſes fade,
And thoſe bare ſhatter'd antlers ſtrew the glade;

Arm

Arm after arm ſhall leave the mouldering buſt,
And thy firm fibres crumble into duſt!—
But MUNDY's verſe ſhall conſecrate thy name,
And riſing foreſts envy SWILCAR's fame;
Green ſhall thy gems expand, thy branches play,
And bloom for ever in the immortal lay.

SECT. XIX.

PRODUCTION OF FLOWERS.

I. Flowers from ſeeds. 1. *Double flowers from ſeeds. Hereditary diſeaſes in plants. Full flowers have no ſtamina. Three kinds of double columbine. Vegetable monſters analogous to animal mules. The ſtamen, piſtil, and calyx, are the moſt unchangeable parts. Double flowers diſtinguiſhed by the calyx, are much more durable than ſingle ones. Double poppies yield more opium. Annual inſects.* 2. *The colours of ſingle flowers from ſeed how varied. Variegation of foliage. Vegetable juices are hyper-oxygenated. This fluid oxygen is converted into gas by the ſun's light; which therefore colours living vegetables, and bleaches dead ones.* II. 1. Flowers from buds. *Double ones how cauſed. Surround the bud with water. Oil, and conſerve of roſes. Their double flowers. Acquired habits.* 2. *How to vary the colour of ſingle ſhrub-flowers, by anther-duſt, by inoculation. Trees how variegated by ingraftment, or made into evergreens.* 3. *How to increaſe the number of flowers.* III. 1. Flowers from roots. *Bulb-rooted flowers. To cauſe their duplicature, break off the flower, raiſe them out of the ground.* 2. *Single bulb-rooted flowers. To increaſe them in ſize or number, take away offsets, crowd their roots. Propagation by offsets. By ſeeds. How broken into colours. Plant them in different ſoils. Tulips break into colours from age.* 3. *Perennial branching roots. Duplicature of their flowers, propagated by offsets, by ſeeds. Their ſingle flowers. How broken into colours. By ſeeds, by tranſplanting.* IV. Eſculent and medicinal flowers. *Vegetable mucilage coagulated by boiling in water, in ſteam. They loſe their green colour in ſteam, Why? Artichoke-ſtalks.* 2. *Cultivation of brocoli. Knobs on its roots.* 3. *Hop. Camomile. Their duplicature.* V. Flowers uſed in the arts. *For dying, ornotto. For ſpinning, cotton, cotton-ruſh, cat's-tail.* VI. Nutritious parts of vegetables. 1. *Muſhrooms. Gluten of Wheat. Oils.* 2. *Sugar. Mucilage. Oil.* 3. *Starch. Meal.* 4. *Alburnum. Barks. Roots of fern and*

and of bryony. 5. *Immature flowers. Honey. Leaf-ſtalks. Leaves. Reſervoirs of nutriment.* VII. Happineſs of organized nature. 1. *Seeds and eggs have not ſenſitive life. Milk gives two-fold pleaſure. Dull animals and diſeaſed vegetables periſh, and give life to more ſenſible ones. Old age unknown before ſociety. Miſery is not immortal.* 2. *Animal abſorption and ſecretion is attended with agreeable ſenſation. Renders matter more ſolid. The ſame in vegetables.* 3. *Strata of limeſtone formed from animal ſhells. Thoſe of coal, clay, ſand, from vegetable ſecretions, gave pleaſure at the time of their production; and are monuments of paſt felicity, and of the benevolence of the Deity.* VIII. Cultivation of brocoli, *a poem.*

THE beautiful colours of the petals of flowers with their poliſhed ſurfaces are ſcarcely rivalled by thoſe of ſhells, of feathers, or of precious ſtones. Many of theſe tranſient beauties, which give ſuch brilliancy to our gardens, delight at the ſame time the ſenſe of ſmell with their odours; yet have they not been extenſively uſed as articles either of diet, medicine, or the arts. For the purpoſe of cultivation they may be divided into thoſe immediately derived from ſeeds, thoſe from buds, and thoſe from roots; to which may be added the eſculent and medicinal ones, and thoſe uſed in the arts.

1. *Flowers from Seeds.*

1. The eye of the floriſt is frequently delighted with double flowers, which ſhew a greater blaze of colour in a ſmall ſpace, and continue ſome weeks longer in blow than ſingle ones; and, though they are properly called vegetable monſters by the botaniſts, may give information to the philoſopher in reſpect to the ſexual generation of vegetables. The method therefore of producing double flowers from ſeeds is a matter of importance, as well as the art of giving to both theſe and the ſingle flowers their moſt healthy expanſion, and the greateſt brilliancy and variety of their colours.

 Though

Though thoſe multiplied flowers, which are ſaid to be full, poſſeſs no ſtamens, or piſtils, and conſequently can produce no ſeeds; yet are they frequently raiſed immediately from ſeeds; for thoſe flowers, which are cultivated with more manure, moiſture, and warmth, than is natural, become more vigorous and larger, and at the ſame time are liable to ſhew a tendency to become double, by having one or two ſupernumerary petals in each flower, as the ſtock July-flower, cheiranthus, and anemone. And what is truly curious, this tendency to duplicature is communicated to the ſeeds of thoſe individual bloſſoms; inſomuch that floriſts are directed to tie a thread round ſuch flowers, which have a ſupernumerary petal, to mark them, and to collect their ſeeds ſeparately; which are ſaid uniformly to produce double or full flowers, if cultivated as above with rather more manure, moiſture, and warmth, than thoſe plants have naturally been accuſtomed to.

The analogy of this circumſtance with the hereditary diſeaſes of animals is truly wonderful; as the children of thoſe parents, who have acquired the gout or dropſy by intemperance in the uſe of fermented or ſpirituous potations, become afflicted with thoſe diſeaſes, as I have frequently obſerved, in a much greater degree by the ſame quantity of intemperance, which originally produced them in their parents; or they acquire the ſame quantity of thoſe diſeaſes by a leſs degree of intemperance, than occaſions them in others, whoſe parents have not uſed fermented or ſpirituous liquors to exceſs.

The luxuriance of flowers, which is believed to ariſe from their cultivation in more nutritive ſoils with greater moiſture and warmth, conſiſts in the increaſe of ſome parts of the flower, and the conſequent excluſion of others; and is diſtinguiſhed by Linnæus into the multiplication and plenitude of flowers, and into proliferous ones. Multiplied flowers conſiſt of double, triple, or quadruple corols; but full flowers are ſo multiplied as to exclude the ſtamina; while in proliferous ones other flowers ariſe from within the principal

principal flower, and frequently from its center. Philof. Botan. p. 80.

It is fuppofed that the ftamina of fome double flowers are converted into petals; but on examination, I fufpect that the number of petals is increafed, and the ftamina prevented from growing by being compreffed by them in their nafcent ftate; as in many of them, I believe, the rudiments of fome ftamina may be feen, as in ranunculus. So when a new flower rifes in the center of the old one, it is fuppofed, that the piftillum is converted into the ftem of a new flower, as in proliferous daify, bellis prolifera; but I fufpect, that the piftillum is prevented from rifing by the immoderate growth of the new flower-ftem; as in fome of them, I am told, the rudiment of the piftillum may be perceived.

Thus monopetalous flowers are doubled or multiplied by the increafed divifions of the limb, as obferved by Linnæus, Philof. Botan. p. 83, who adds, that the metamorphofis of Englifh foapwort is very fingular, as its five petals are transformed into one petal, and that in opulus flore globofo the central florets become fimilar to thofe of the circumference, acquiring wheeled corols, and being barren: in thefe cafes the ftamens cannot be changed into corols, as the number of corols is not increafed. Afterwards, in p. 84, the fame illuftrious author obferves, that in double lychnis the rudiment of the common piftil is prefent.

The luxuriance of flowers therefore confifts in the multiplication of the corols or nectaries, which laft are properly an appendage to the former; and the prevention of the growth of the male and female organs is the confequence. Thus the flower of aquilegia, columbine, has three kinds of plenitude: 1. the petals become multiplied, and the nectaries excluded; 2. the nectaries are multiplied, and the petals excluded; 3. the nectaries are multiplied, the petals remaining. So that there are five petals, and between each of thefe three nectaries, which exift within each other.

A curious

A curious analogy here alſo exiſts between theſe vegetable monſters and thoſe of the animal world; as a duplicature of limbs frequently attends the latter, as chickens and turkeys with four legs and four wings, and calves with two heads. And in mules the parts ſubſervient to generation become deficient, whence they cannot propagate their ſpecies; exactly as in theſe full flowers, which can thence produce no ſeed. And in reſpect to botanic ſyſtems, it may be obſerved from theſe vegetables of luxuriant growths, that the ſtamens and piſtils are leſs liable to change than the corols and nectaries, and are therefore more proper parts for the claſſification of plants; on which idea Linnæus has conſtructed his unrivalled ſyſtem. And laſtly that the calyx, or perianth, is the next moſt unchangeable part of the flower, as this is ſeldom doubled or multiplied; and that hence by inſpecting the calyx the genera of many double flowers may be detected; thus the double ranunculus poſſeſſes a calyx, but the double anemone is without one, like the ſingle ones of thoſe genera.

The greater duration of double flowers than ſingle ones is ſo remarkable in ſome poppies, that their ſingle flowers loſe the corolla in a few hours, while in the double ones it continues ſeveral days: this circumſtance is well worthy the attention of thoſe, who cultivate poppies for the purpoſe of wounding the head, which incloſes the ſeeds, for the opium, which thus exſudes. As poppies with double flowers may probably be capable of yielding opium, before they ſhed their flowers, and as long as other poppies, after they ſhed them, Dr. Smith aſcribes this event to the organs of reproduction being obliterated, and the conſequent want of impregnation; by the great ſtimulus of which he thinks the vegetable irritability may be ſooner exhauſted in ſingle flowers: and adds, "that on the ſame account many plants reſiſt a greater degree of cold for ſeveral winters before flowering; but after that event they periſh at the firſt approach of cold, and can by no art be preſerved ſo as to ſurvive the winter."

And repeats an obfervation from Linnæus, that the piftilla of the female hemp, cannabis, continued much longer to exift when not expofed to the male pollen, than thofe piftilla on which the pollen had been effufed. Tracts on Nat. Hift. p. 177.

It may be obferved, that many infects may be called annual ones as well as many vegetables, and die, as foon as they have provided the eggs or feeds for the reproduction of their fpecies, as the filkworm, and, I fuppofe, all the kinds of moths and butterflies; many of which take no food at all, after they have acquired their organs of generation and their amatorial paffion, and yet appear fat and active; and others live only upon honey, and feem to die as foon as that paffion is gratified, probably from having no further pleafureable ftimulus to excite the animal power into activity, rather than from its total exhauftion; becaufe other animals, whofe exiftence is not naturally fo fhort, are not injured or deftroyed by the moderate ufe of the powers of reproduction; and that power leaves them long before their death. An experiment to fhew, whether the moths of filkworms would live longer if deprived of their paramours, might be worth the attention of naturalifts; and alfo, whether the butterflies of our climate might not be preferved during the winter, if fed with honey like bees, and kept from exceffive cold. I directed fome honey to be offered to the filkworm-butterflies, which they would not attend to, though they may probably feek for it in their native climates.

2. Varieties in the colours of fingle flowers raifed from feeds may probably be generally acquired by fowing near together thofe of the fame fpecies, which already poffefs different colours; fo that during the difperfion of their anther-duft by the wind, or otherwife, they may intermix and adulterate each other. Or this may be more certainly effected by bending the flowers of one colour, and fhaking the anther-duft over thofe of another colour. In this manner, I fuppofe,

ſuppoſe, it happens, that the beds of centaurea cyanus become of ſuch various and beautiful ſhades of blues, purples, and whites.

Another method of giving variety of colours to ſeedling flowers conſiſts in ſowing them on natural ſoils, or on factitious compoſts, which differ much from each other in reſpect to vegetable nutriment, and perhaps in reſpect to their colour, as ſome animals change their natural colours when in different ſituations of ſoil. As frogs much reſemble the colour of the ſoil on which they live, and our domeſticated horſes, dogs, cats, rabbits, pigeons, and poultry, change their colours into endleſs varieties, owing to the difference of their nutriment or ſituation. But obſervations and experiments are wanting on this ſubject in reſpect to the colours of ſeedling flowers, as well as in reſpect to the variegation of the leaves of ſhrubs and trees; which laſt originates probably from ſoil or ſituation, and may be propagated by ingrafting.

As the origin of double flowers is believed to reſult from the luxuriant growth of the plant, owing to too much nouriſhment, moiſture, and warmth, ſo the origin of new colours in flowers, and of variegated foliage, is thought to occur from the innutrition of the ſoil, on which they grow, compared to that which they have naturally been accuſtomed to, or from defect of moiſture and of heat; which is countenanced by the dwarfiſh ſize of ſuch plants in general, and eſpecially by the leſſened ſtature of tulips, when their petals break into variety of colours.

The proximate cauſe of the change of colours in flowers or foliage muſt be ſought from the modern acquiſitions of aerial chemiſtry. The preſence of oxygen gas deprives dead vegetable fibres, as cotton-wool and the threads of flax, of their colour; that is, it bleaches them; which is probably owing to its uniting with the colouring matter and forming a new acid, which is tranſparent. Thus the hyper-oxygenated muriatic acid almoſt inſtantaneouſly deprives cotton and linen of their colour; and the ſun's light on moiſtened linen

linen ſpread upon the ground ſeems to decompoſe the water, and the oxygen thus detached whitens the linen. The etiolation or blanching of living vegetables on the contrary ſeems to originate from the want of the ſun's light to convert into gas the fluid oxygen; which, by diſſolving their colouring matter, and forming new and perhaps taſteleſs acids, deprives them of colour. Hence the water, which vegetables perſpire in the ſunſhine, becomes hyperoxygenated, which has much puzzled philoſophers to account for; and the oxygen riſes from it without decompoſing it; which laſt circumſtance is evinced by the total abſence of the ſmell of hydrogen, which ſo powerfully affects our noſtrils, when a ſpoonful of water is thrown on burning coals.

Now as plants, which grow leſs vigorouſly from defect of nutriment, moiſture, air, or warmth, may acquire or poſſeſs leſs oxygen to diſſolve their colouring matter, their ſtructure may approach towards that of dead vegetables; and hence they may become bleached inſtead of coloured by the influence of the ſun's light, eſpecially in thoſe parts where their vital functions are performed with leſs vigour; ſo an etiolated vegetable, as a blanched plant of celery, apium graveolens, becomes green in a few days, when expoſed to the light and air; and white again, if deprived of life, and expoſed to the ſunſhine and dews.

The immediate cauſe of the various colours of ſome flowers, as of poppies, might be a ſubject of curious inveſtigation. I once ſuppoſed, that the thinneſs of the pellicle of ſome flowers might occaſion them to reflect different colours, as is ſeen on dropping a drop of oil from a bridge on the water below on a bright day. But colours thus produced vary with the ſituation of the obſerver, in reſpect to the obliquity or angle of reflection, in which they are ſeen; and are thence variable with every motion of them, as thoſe colours ſeen on ſoap-bubbles, and on mother-pearl, and on the Labradore-ſtone, and on ſome ſilks. For thoſe colours depend on the thinneſs of the reflecting ſurface, which when ſeen more obliquely become thicker; and then reflects thoſe colours, which paſſed through thinner plates; in the ſame manner as the red light of the ſetting ſun is reflected from glaſs windows, ſeen very obliquely by the obſerver.

The colours of flowers therefore, as they are not variable by the obliquity, with which they are ſeen, like thoſe of mother-pearl card-fiſh, do not depend on the thinneſs of their pellicle; but, I ſuppoſe, to the greater facility that ſome parts of them poſſeſs in parting with their oxygen, when expoſed to the ſun's light, than other parts of them; for all flowers are more or leſs etiolated, before they firſt open. In the ſilk manufactory a variable colour is produced by making the warp of one colour and the woof of another; perhaps the variable colour of a peacock's tail may be owing to a mixture of different coloured down placed in lines near each other.

II. *Flowers from Buds.*

1. The flowers ariſing from the buds of ſhrubs or trees are liable to become double or full by the multiplication of their petals, as thoſe of roſes, cherries, hawthorn, peach, roſa, prunus, ceraſus, crategus oxyacantha, amygdalus perſica. Which tendency to duplicature, as in the flowers of annual plants, is probably owing to the too vigorous growth of the bud from a too nutritious ſoil, or the combination of abundant moiſture and warmth, and would probably be forwarded by ſurrounding the bud itſelf frequently with water; as is ſo beautifully ſeen in thoſe plants, which have a cup round their joints to preſerve for a time the rain, which falls upon them, as round the joints of dypſacus, teaſel, ſilphium, tillandſia, and nepenthes.

It is remarkable, that though the duplicature of many flowers is believed to have been owing to the more nutritious ſoil, in which they

they have been cultivated, yet that, when tranfplanted into lefs fertile foils, or ingrafted on lefs luxuriant trees, they ftill retain their tendency to duplicature; which can only be afcribed to the continuance of an acquired habit, or to the fucceffion of hereditary difeafes, fo frequently obferved in the animal fyftem.

This duplicature of flowers from buds is generally propagated by ingrafting the fcions of fuch, as bear multiplied petals, on fimilar plants, which bear fingle flowers ; and may be of fervice not only for beauty, but for the purpofe of increafe in thofe plants, the petals of whofe flowers are confumed for any purpofe, as the leaves of rofes. A gentleman at Nottingham annually diftils a profitable quantity of effential oil of rofes, by collecting all of them he can purchafe in the neighbourhood during the feafon; and this by the ufual procefs, which is not difficult though tedious. And a furgeon at Stafford has introduced an agreeable and profitable kind of agriculture, by planting half an acre of ground with red rofes, and converting the flowers into conferve with fugar, or by fimply drying them for the London market.

2. It is probable, that numerous varieties of colour in the fingle flowers of fhrubs, as well as thofe of annual plants, might be obtained by fhaking the anther-duft of one variety over the ftigma of another, where any difference of colour already exifts in the fame fpecies. And perhaps fome changes of colour of the flowers might be produced by inoculating the buds of a fhrub, whofe flowers are of one colour, into the branches of another variety of the fame fpecies or genus; as the variegation of the foliage of plants is faid to have been produced in this manner, according to the affertions of Mr. Bradley and Mr. Laurence, who budded a fpotted paffion-flower and a ftriped jafmine on thofe, which were not variegated, and produced a fimilar variegation of them, as related in Sect. V. 1. This has been afcribed to the abforption of fome infectious matter from the inoculated bud, which propagated a fimilar difeafe to the whole tree; and

has thence been ufed as an argument in favour of a vegetable circulation of juices.

A fimilar fact is alfo afferted by Mr. Milne. He fays, that "an evergreen tree ingrafted on a deciduous one determines the latter to retain its leaves; this obfervation is confirmed by repeated experiments, particularly by grafting the laurel, laurocerafus, an evergreen, on the common cherry, cerafus; or the ilex, an evergreen oak, on the common oak." Botanical Dict. Art. Defoliatio. All thefe feem to want further experiments to authenticate the facts fo delivered on the authority of ingenious men.

3. To increafe the number of the flowers of fhrubs, all thofe arts are applicable, which are defcribed in Sect. XV. 2. for the production of fruit on wall trees; which, when the tree is of a proper age, confift, 1. in bending down the viviparous branches to the horizon, which renders them oviparous; 2. by twifting a wire, or tying a cord round the viviparous branches; 3. by wounding or cutting away a narrow cylinder of the bark; 4. by tranfplanting or cutting off fome of the roots; 5. by cutting away the central or viviparous branches; 6. by ingrafting.

III. *Flowers from Roots.*

1. Many bulb-rooted flowers are defervedly in great eftimation by florifts, as the tulip, hyacinth, lily, colchicum, crocus, fritillary, &c. and of thofe many are liable to become double, which adds in general fo much to their fplendour and to their duration, as narciffus, hyacinth, colchicum, tulip.

The immediate caufe of duplicature or multiplication of the petals of thefe flowers is probably fimilar to that of thofe above mentioned, and originates from their luxuriant growth, owing to the fertility

fertility of the ſoil, and the abundance of moiſture and of warmth in combination.

Other circumſtances, which may add to their luxuriant growth, may alſo contribute to their duplicature; ſuch as by breaking off the flower as ſoon as it begins to fade; and thus, by preventing the nutritious vegetable juices from being expended in the growth of the ſeeds, more of it may be derived to the principal ſucceeding bulb.

Thus it is aſſerted, that the preventing ſome annual plants from flowering lengthens their lives, which it may effect by occaſioning them to produce new root-ſcions, and thus to become perennial vegetables. The very ingenious Mr. Bogle, in the papers of the Bath Society, believes that wheat, oats, and barley, may be made perennials, if they are eaten down by cattle or ſheep, or cut by the ſcythe or ſickle, ſo as to prevent them from producing ears.

As tulip-bulbs raiſed from ſeed produce a larger bulb the ſucceeding year, and again a larger with a different leaf on the third year, and ſo on till the fifth or ſixth, the bulbs thus annually improving till they flower; and even after they flower they are believed to continue to improve for ſome years, till the colour of the petals become ſtriped: I ſuſpect that the art of procuring a great duplicature of the petals of theſe flowers conſiſts in breaking off the flower-ſtem on the fifth, ſixth, and ſeventh years, from the ſowing of the ſeed; that is, for a year, or two, or three, after the flower-ſtem firſt appears, as noted in Sect. VIII. 1. 3. And that the tendency to duplicature will continue in the ſucceeding bulbs by the acquired habit, as in the hereditary diſeaſes of animals.

And ſecondly, theſe flower-roots become more luxuriant by raiſing them out of the ground, as ſoon as the leaves wither, which are the parents of the new bulbs; and then by taking away the ſmaller or collateral new bulbs from the principal one, which might otherwiſe incommode its growth by their vicinity, and conſequent compreſ-

ſion,

ſion, both theſe methods are of equal uſe to enlarge and render more vigorous the ſingle flowers of bulb-roots, as well as to increaſe their tendency to duplicature.

2. The ſingle flowers of ſome of theſe plants may be probably not only enlarged, but ſo ſtrengthened as to ripen their ſeeds in this climate, by nicely laying bare the root, and taking from it the new progeny; whether a ſingle new bulb, as in orchis maſcula, or the numerous ones of hyacinth, tulip, or lily of the valley; as by theſe means the vegetable nutriment is not expended on the new bulbs, and probably more of it may thence be derived to the flower. See Sect. XVII. 1. 3.

Another method of increaſing the bulb-rooted flowers in ſize or number conſiſts in crowding their roots in garden-pots, or by not annually tranſplanting them; and thus by preventing their offsets from being formed, or by decreaſing the number or vigour of them; thus lily of valley, and jonquil, ſeldom afford large or numerous flowers, till they have remained three or four years in the ſame ſituation; but muſt nevertheleſs be then occaſionally in part tranſplanted, leaſt the roots ſhould die from being ſo crowded as not to form each of them one annual new bulb, which is their mode of reproduction.

The uſual method of propagating bulbous roots has been by the ſmaller offsets, which are formed annually round the principal or central new bulb, as in tulips; which central new bulb has commonly been miſtaken for the old root; by this mode of propagation the ſimilarity of the new progeny to the parent is nicely preſerved; and on that account ſome of theſe new roots of tulips and hyacinths have been ſold at extravagant prices. For the circumſtance of this mode of reproduction ſee Sect. IX. 3. 2.

But in reſpect to producing variety of colour in the ſingle flowers of bulbous roots, the moſt effectual method, I ſuppoſe, muſt be by ſowing their ſeeds, and waiting a few years, till their ſucceſſive bulbs

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at length produce flowers, as defcribed in Sect. XVII. 1. 2. and particularly if the anther-duft of one variety in refpect to colour be fhed on the ftigma of another variety.

Another method of producing a change or variety of colours in bulb-rooted flowers may be by planting them every year, till they flower, on very nutritious foil, with an abundant combination of moifture and of heat, as thefe two elements fhould exift together to effect the moft luxuriant growth of vegetables. And after they have flowered, or on the year in which they are expected to flower, they fhould be tranfplanted on a lefs nutritive foil, with lefs heat and moifture. Or probably this lefs quantity of nutriment, heat, and moifture, might be ufed at the commencement of their growth, or even at fowing their feed, with fimilar effect of fooner breaking into variety of colours.

The beauty of the double yellow tulip, and its greater longevity, much recommend it to common eyes ; but the endlefs variety in the colours of fingle tulips has long and defervedly been the admiration of florifts. The curious event of their breaking into various colours from an uniform purple, a year or two after their firft flowering, and at the fame time of their lofing nearly one third of the height of their ftems, feems to indicate, that this effect refults not from the debility of age, but from the acquifition of hereditary difeafes, as thefe new colours, into which they break, afterwards remain for uncounted generations, and may in this refpect be compared to the canker in apple-trees, mentioned in Sect. XIV. 1. 3.

This change of colour from darker to lighter in tulips may probably be accelerated or increafed by keeping the roots long out of the ground in dry or warm apartments, fo as to harden their fibres, and diminifh the diameters of their fecreting veffels, and thereby hindering their abforption of colouring molecules, fimilar to grey hairs produced on animals by age or external injury of the part. This would feem to obtain in tulips, as when they break into colours,

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they lofe one third of their fize, and confequently the diameters of their fecretory and of their abforbent veffels muft be much diminifhed.

New kinds of varieties in the fituations or production of white parts of the petals of flowers might be caufed, I fufpect, by compreffing fome parts of them before the flower opens, by tying fine threads round the calyx, which inclofes them; as many darker coloured cats and dogs have all thofe parts lighter or quite white, which have been compreffed together, as they lay in their fetus ftate in the uterus; an inftance of which exifts in a black male cat, which now lies upon the hearth, and an inftance of a black terrier bitch is defcribed in Zoonomia, Vol. II. Clafs I. 2. 2. 11. This may be worth the attention of florifts and flowerfellers; and it is probable, that the white ftreaks in dark flowers may have been thus produced by their greater compreffion in the calyx, before the flower opens.

3. The caufes of duplicature in perennial flowers with branching roots, as ranunculus, caltha, hepatica, anemone, cheiranthus, dianthus, filene, wallflower, carnation, catchfly, are probably fuch as afford a general luxuriancy of growth to thofe vegetables, and may be certainly propagated by offsets from thofe roots, or by laying their branches in the ground, fo as to exactly refemble their parents. Many of thefe double flowers may alfo be procured by collecting the feeds from fuch fingle flowers of the fame fpecies, as poffefs a fupernumerary petal; which, if fowed on fertile ground, will prefent us with double or multiplied flowers, as the anemone and july-flower mentioned in No. I. 1. of this Section.

The effect of breaking the fingle ones into varieties of colour, which, in anemones and poppies as well as in tulips, are uncommonly beautiful, is probably owing to the lefs fertility of the foil, or lefs fupply of heat and moifture, where they have happened to refide, and that more effectually if they were removed from more favourable fituations.

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The varieties of the ſingle flowers alſo of thoſe roots may be propagated unchanged, as well as the double ones, by dividing the roots or tranſplanting the offsets, or by laying their branches in the ground, as of pinks and carnations. Other varieties may be procured by collecting ſeeds and ſowing them in diſſimilar ſoils and ſituations; and ſuch flowers as are of approved beauty, may probably be occaſionally ſtrengthened and enlarged by depriving them in part of their offsets early in the ſeaſon; or may be broken into colours by keeping the roots ſome weeks or months out of the ground in the autumn in dry or warm apartments.

The colours of flowers of this kind, I believe, are frequently changed by ſituation; in my garden ſome roots of comfrey, ſymphytum, with purple flowers had long exiſted on a moiſtiſh border; and laſt year other roots, I ſuppoſe from the ſeeds of the former, grew in a dryer ſituation, and bore white flowers. And Mr. Bradley aſſerts, in his Philoſ. Account of Nature, p. 71, that ſome roots of purple hepatica, which were removed from Tothill-fields to Henley on the Thames, became white; and became purple again, when they were returned to their native ſituation.

IV. *Eſculent and Medicinal Flowers.*

1. The eſculent flowers moſt in uſe at our tables have their mucilage in ſome degree coagulated by boiling them in water or in ſteam, and are conſumed before their maturity, as thoſe of artichoke, cinara ſcolymus; of mercury, mercurialis; of ſea-cale, crambe maritima; and of brocoli and cauliflower, braſſica oleracea, italica and botrytis. The flowers of the naſturtion, tropeolum majus, poſſeſs an agreeable acrimony, and are eaten raw, ſhred with the freſh leaves of lettuce, young muſtard plants, or red cabbage. Other flowers are uſed for domeſtic or medicinal purpoſes, as thoſe

of hops, humulus lupulus, camomile, anthemis nobilis, roſes, cardamine, violets.

The three foremoſt of theſe, the artichoke, and mercury, and ſea-cale, are perennial plants; and, as they put forth numerous root-ſcions or offsets, may have their principal ſtem much invigorated, and will conſequently produce larger flowers, by taking away many of theſe offsets, ſo as to leave but two or three on a root. And as the ripening of the ſeed is no object, a greater abundance of moiſture, than theſe plants have been naturally accuſtomed to, with proportional increaſe of warmth in reſpect to ſituation, will forward their growth, and increaſe their ſize.

A great part of the nutritious mucilage in the artichoke is placed in the upper part of the ſtem, as well as in the pericarpium of the flower, which ſhould therefore be boiled along with it for the purpoſe of coagulation; and might then probably be managed ſo as to reſemble ſagoe, if granulated by paſſing it through ſieves.

The art of boiling vegetables of all kinds in ſteam inſtead of in water, might probably be managed to advantage, as a greater degree of heat might be thus given them, by contriving to increaſe the heat of the ſteam after it has left the water; and thus the vegetable mucilage in roots and ſeeds, as in potatoes and flour-puddings, as well as in their leaves, ſtems, and flower-cups, might be rendered probably more nutritive, and perhaps more palatable.

But many of the leaves of vegetables, as the ſummits of cabbage-ſprouts, loſe their green colour by being boiled in ſteam, and look like blanched vegetables. This etiolation of ſome vegetables by ſteam is probably owing to its diſſolving their colouring matter, which may then become decompoſed; and may render them leſs agreeable to thoſe who chooſe by the eye rather than by the palate; which green colour is however heightened by boiling them in ſome hard waters which contain diſſolved lime or ſea-ſalt, or by a ſlight admixture of common ſalt with ſoft water. An effect which is is owing to the evaporation of a part of the marine acid, and to the remaining alkali, which was the bafis of it, when applied to bluifh vegetables converting them into green, as in the common experiment of adding falt of tartar to fyrup of violets; or, according to the cuftom of fome cooks, who add a little potafh, or fixed vegetable alkali, to the water, in which young peas are boiled to make them green, and afterwards a very little fugar to fweeten them.

The fame effect of making vegetables green, when boiled in other kinds of hard waters, is probably produced by the lime, which abounds in them; and which like the vegetable alkali when the aerial acid, which was united with it evaporates, is faid to convert bluifh vegetable colours into green ones.

The nutritious mucilage refides likewife in the young ftems of mercury, which fhould therefore be eaten before the flower begins to open. The ftalks and immature flowers of fea-cale are fimilar to good brocoli, if eaten young; though many gardeners prefer the blanching them, which fupplies an early and agreeable repaft, defcribed in Sect. XIV. 3. 3. Afparagus does not perhaps properly belong to this fection, as the ftem is eaten, before the flower becomes vifible.

2. The cultivation of brocoli and cauliflower muft be very fimilar, except as to the feafons of the year, as they are varieties of the fame fpecies of plant of the cabbage family. The following directions for the cultivation of brocoli were fent me by Edward Tighe, Efq. an ingenious gentleman of Ireland, along with an elegant Latin poem on the fame fubject, a free tranflation of which is placed at the end of this fection.

" Brocoli may be fo managed as to fupply the table with a delicious and falutary vegetable during the months of November, December, January, February, March, April, and May.

1. Procure prime feed from Rome or Naples both for early and late fowing.
2. Sow at the ceffation of the vernal fnows, and repeat it once a month till the end of May, or longer.
3. When three leaves appear, tranfplant them; and when fix leaves appear, tranfplant them again. Afterwards in June, July, and Auguft, tranfplant them two or three feet afunder, to remain.
4. During September and October the ground muft be loofened, and repeatedly cleared from weeds and ftones; and the plants earthed up to preferve their roots from the froft, and to prevent their being injured by the equinoctial winds.
5. Water them occafionally with water impregnated with dung.
6. Sow and plant them far from hedges, trees, and walls.

The head is generally completed in five or fix days from its firft appearance, and fhould not remain much longer; the ftalk fhould be boiled with the flower, and peeled in the kitchen, before it is brought to the table."

Some kinds of Italian brocoli are faid to produce fome knobs or bulbs at their roots, which are fuppofed to be for the purpofe of raifing other ftems; if this laft circumftance be afcertained, they fhould be broken off, when the principal ftem is tranfplanted; like the new root of orchis to enlarge the flower, mentioned in Section XV. 2. 4. But they may be fimply a refervoir of nutriment for the principal ftem, as in carrots and turnips; in that cafe they fhould certainly remain, and be tranfplanted along with the ftem.

3. In refpect to the flowers of hop, humulus lupulus; and chamomile, authemis nobilis; as well as thofe of rofes, violets, cardamine, and the nafturtion above mentioned; as their petals only are required, it would add much to their quality, if they could be cultivated in their double or multiplied ftate, as is generally indeed practifed

practifed in refpect to rofes and chamomile ; many acres of the latter of which are cultivated near Chefterfield in Derbyfhire, and are fold, I am informed, to mix with hops, when thofe crops are deficient, as well as for the purpofes of medicine. What might be the effect of endeavouring to introduce a duplicature or multiplication of the flowers of artichoke, fea-cale, cauliflower, and brocoli, has not, I believe, been experienced.

v. *Flowers ufed in the Arts.*

1. The beautiful membrane, which covers the feeds of euonymus, or fpindle-tree, and of the bixa of South America, is faid to be manufactured into the anotta, or arnotta, ufed in colouring cheefe; but I am told that madder, made from the root of rubia tinctoria, is fold frequently in its ftead, and may be readily grown by farmers in their own gardens. Few flowers are ufed in the art of dying, their colours are fo fugitive, as they readily bleach when expofed to the light, and cannot be kept long even in the herbariums of botanifts without lofing their colours ; which is believed to be owing to the oxygen of the atmofphere being feparated from the aerial water by the fun's light, and converted into a gas combined only with heat or light, and in that ftate more readily uniting with the colouring matter of flowers, and producing a new acid, which is tranfparent, colourlefs, or white, or is diffolved and wafhed away by the dews or rains.

The blue colour of the flowers of violets has been extracted by water, and preferved by the addition of fugar converting it into fyrup for the purpofes of medicine in part, but chiefly for thofe of chemiftry, to fhew the change of vegetable blues into greens by an admixture of fixed alkali, as falt of tartar or potafh ; and into red by the admixture of an acid, as thofe of fulphur, nitre, or marine falt.

2. Another very important flower, which is fuffered to grow to maturity for the purpofe of ufing the fine fibres which wing or invelope its feeds, is that of the cotton plant, goffypium; which, as it requires fo much lefs preparation than the fibres of the ftems of flax and of hemp or nettles, is likely to become the principal clothing of mankind; and efpecially fince the art of fpinning it was brought to fuch wonderful perfection by the genius of Sir Richard Arkwright, who difcovered that two fets of rollers moving with different velocities would draw out the fibres of cotton into a fine thread more accurately than could be done by the human hand, as well as more expeditioufly, along with much other very ingenious machinery.

There are two bog or water plants in our moraffes, which produce much vegetable fibres attached to their feeds, one of thefe is the typha, or cat's-tail; and the other eriophorum, or cotton-rufh. The fibres of the former are fhort and coarfe, but might ferve perhaps to ftuff cufhions, or even coarfe beds; thofe of the latter are longer, and perhaps fine enough to fpin. And as both thefe only grow on bogs or in water, where we at prefent cultivate no ufeful vegetables, one, or both of them, might poffibly be worthy the attention of thofe, who poffefs aquatic or marfhy fituations. The cultivation of the cotton plant belongs to warmer climates, and may probably require abundant water for its vigorous growth, as well as the typha and eriophorum of this country.

VI. *Nutritious parts of Vegetables.*

1. Having treated of the cultivation of fruits, feeds, roots, barks, leaves, woods, and flowers, an important queftion prefents itfelf; which

which of them may fupply the moft nutrition to mankind, or to other animals?

It may be anfwered firft, that thofe vegetables, or parts of vegetables, which approach neareft to the nature of animal bodies, are moft likely to fupply them with the moft nutriment; as the efculent mufhrooms, and the gluten of wheat, and the oils of feeds and kernels. The former clafs of plants feems to connect the animal and vegetable kingdoms of nature, as fpoken of in Sect. XVII. 2. 5. and though many of them poffefs an acrid, and fome of them an intoxicating quality, it is probable that the former might be deftroyed, and the latter diminifhed, by the heat employed in cookery. This fhould neverthelefs be attempted with due caution; fince, though one kind of vegetable acrimony, as that of water-creffes and of cabbages, is much diminifhed or deftroyed by a boiling heat, yet that of the leaves of arum maculatum, and of arum arifarum, I found by experiment, was not decreafed by boiling. And a few grains of the powder of lycoperdon, puff-ball, have lately been recommended in epileptic fits, and may thence poffibly poffefs a powerful narcotic quality. The gluten of wheat is fuppofed to approach towards the coagulable lymph of animal bodies, as referred to in Sect. XVI. 7. 1. and was once, I believe, advertifed as an alimentary powder, and recommended as a nourifhment of the moft portable kind for the fuftenance of marching armies. And laftly the oils of vegetables approach much to a fimilitude with thofe of animal bodies.

2. Secondly, it may be anfwered, that fince the chyle of all red-blooded animals is believed to be nearly fimilar, and to confift principally of fugar, mucilage, and oil; the laft of which ingredients renders it white by its infolubility in water, and thence diftinguifhes it from the vegetable chyle or fap-juice of trees, which is tranfparent, and is believed to confift principally of fugar and mucilage without oil; thofe parts of vegetables which contain the greateft quantity of

theſe ingredients which compoſe animal chyle, or are convertible into them by the power of digeſtion, may be ſuppoſed to contain the moſt nutriment for red-blooded animals.

To this may be added, that the nutritive quality of ſugar is inconteſtably evinced from the known fact, that the ſlaves in the ſugar iſlands become in better condition during the ſugar ſeaſon, though they are compelled to labour harder. The nutritive quality of ſimple mucilage was ſhewn in a remarkable inſtance on record; where a caravan by ſome misfortune had conſumed or loſt all their other proviſions, and lived many weeks on the gum arabic alone, which conſtituted their principal merchandiſe. The nutritive quality of oil is obſervable in the proceſs of feeding cattle with oil-cake, and in the habits of the natives of the northern latitudes, who uſe the oil of fiſh for both meat and drink, and derive from it their principal nouriſhment.

Sugar is known to be the ſame, from whatever vegetable it is extracted, whether from the fruit of the vine or apple-tree, from the joints of the ſugar-cane, from the ſap-veſſels of the maple, from the alburnum of the manna aſh, from the ſeeds of germinated barley and rice, from the roots of beets, carrots, and potatoes, or, laſtly, from the nectaries of flowers. The expreſſed oils of vegetables are alſo believed not much to differ from each other in reſpect to the nutriment they contain, though ſome of them may approach nearer to the nature of animal fat; as the painters diſtinguiſh them by their greater aptitude to dry, when mixed with their colours and expoſed to the air. But the word mucilage has been uſed for ſtarch, which will not diſſolve in cold water, as well as for gum arabic, and other mucilages properly ſo called, which will diſſolve in cold water, and even for the gluten of wheat, which will not diſſolve in either hot or cold water. We may therefore conclude, that thoſe parts of vegetables, which contain the moſt of theſe materials, are the moſt

nutritive,

nutritive, if they do not contain along with them ſome noxious materials united with their ſalutary ones, and which cannot be readily ſeparated from them.

3. Though the parts of vegetables, which poſſeſs much oil, ſugar, or mucilage, may afford more expeditious nutrition, as they conſtitute the ingredients of the chyle of all red-blooded animals; yet there are other materials, which appear to be ſo readily convertible into ſugar or into mucilage, as perhaps nearly to ſupply an equal quantity of nutriment. Thus by the proceſs of germination, as when ſeeds of barley are converted into malt, and when roots pullulate in our ſtore-rooms, as of onions or potatoes; the farina, conſiſting of meal or ſtarch, is in part converted into ſugar, and in part into mucilage; ſimilar to this proceſs of germination appears to be that of ripening, by which the auſtere juices of fruits are tranſmuted into ſweet ones; and alſo the culinary proceſſes of baking or boiling, by which the auſtere juices of unripe pears are changed into ſweet ones by the application of heat, as mentioned in Sect. VI. 5. But another more expeditious converſion of vegetable materials into ſugar is by the digeſtion of animals, which may be truly termed a ſaccharine proceſs; as appears in thoſe, who labour under diabates, as by evaporating the urine of one of theſe patients, ſixteen ounces of impure ſugar were daily extracted for ſome time. Zoonomia, Vol. I. Sect. XXIX. 4.

Hence, though the oily kernels of nuts, walnuts, almonds, and the oily ſeeds of flax, hemp, rape, may contain moſt expeditious nutriment; and next to theſe the ſaccharine fruits of figs, dates, raiſins, and the ſweet roots of beet, mungel-worſal, ground artichoke, helianthus tuberoſus, parſnip, carrot, may contain expeditious nutriment. Yet the more farinaceous ſeeds, as of wheat, peas, rice, barley, oats, and buck-wheat, polygonum fagopyrum, and the roots of potatoes, which contain ſtarch, and flour, and mucilage, which are convertible into ſugar in the ſtomachs of animals, and are probably by that digeſtive proceſs, and their previous maſtication in the mouth, mingled with more animal coagulable lymph, as the ſaliva, gaſtric, and pancreatic juices, and may thus ſupply a more animalized nutriment than the former; and may on that account contribute more to ſtrengthen the ſyſtem. Of theſe ſeeds and roots it appears probable, that thoſe, which contain the moſt ſtarch or gluten, as wheat, afford the moſt nouriſhment, as they are believed to make the beſt bread.

4. The alburnum, or ſap-wood, of moſt trees in the winter months probably contains much nutritious matter; whence it is ſo ſoon deſtroyed by fermentation or putrefaction when deprived of life; and by inſects, when it is deprived of its protecting bark. This nutritious matter might be obtained by grating, or raſping, or pounding it, and boiling the powder or ſaw-duſt thus procured. The bark of all thoſe vegetables, which are armed with thorns or prickles, is believed to contain much nutritious matter, which their armour was deſigned to protect; as the inner barks of elm, holly, gooſeberry, whin or gorſe, contain much nutritive mucilage; thus the deer in Needwood Foreſt greedily peel the bark from the branches of holly, which are cut from the ſummits of thoſe trees, where they have no prickles, as mentioned in Botanic Garden, Vol. II. note on Ilex. And horſes are ſaid to be well nouriſhed by gorſe, if the prickles are previouſly deſtroyed by rolling a ſtone over it, as the tanners bruiſe their oak-bark; and ſome horſes are ſaid to be ſo fond of it, and ſo wiſe, as to bruiſe young gorſe-buſhes with their feet, and then to eat them.

Fern roots are ſaid to be eaten by the natives of New Holland, and in other countries in times of ſcarcity; but as their farinaceous or mucilaginous matter is included in ligneous fibres too hard for maſtication, the method of cooking it is ſaid to conſiſt in boiling the root, and then extracting the fibres by hammering it to pieces. The root of white bryony, which grows to a great ſize in our hedge-bottoms,

toms, is ſaid, by M. Permentier, to poſſeſs a quantity of ſtarch, which was capable of being waſhed from the acrid mucilage by grating it into cold water, and of being manufactured into an agreeable and ſalutary bread; like the bread made from the caſſava, which is ſaid to undergo a ſimilar proceſs, by expreſſing ſome of the acrimonious mucilage previous to the application of the heat of cookery. Which however not only deſtroys the acrimony of many vegetables, as of water-creſſes, cabbages, and the ſkins of potatoes, but is alſo believed to render ſome of them more nutritive by coagulating their mucilage, which was previouſly combined with too great a proportion of water.

5. It would appear therefore in general, that the ſeeds or kernels of vegetables afford the moſt nutriment; next to theſe their fruits and roots; and afterwards the alburnum or bark. Some of the flowers alſo in their early ſtate before impregnation, as thoſe of artichoke, cinara, and cauliflower, braſſica, are nutritious from the mucilage, which they poſſeſs; and ſome ſeeds already impregnated, but ſtill in their immature ſtate, along with their huſks or capſules, as thoſe of kidney-bean, phaſeolus, and of very young peas, afford a ſalutary nutriment. And laſtly all flowers after the expanſion of their corols ſecrete honey; which ſupplies food to innumerable inſects, who plunder it, as well as to mankind. In the baſes of many leaves another ſaccharine or mucilaginous juice is ſecreted, as at the joints of graſs, on the bulbs of onions, and at the lower parts of the leaves of cabbages, and around the ſtems of aſparagus, mercury, and hop-buds, during the early ſtate of their flowers; but the leaves themſelves, like the lungs of animals, ſeem to poſſeſs leſs nutritious aliment than many other parts of their ſyſtem.

VII. *The Happineſs of Organic Life.*

All organized nature may be divided into ſtationary organizations, and locomotive organizations; the former of which are called vegetables, and the latter animals. All thoſe parts of vegetables, which are moſt nutritious to animals, conſiſt, as obſerved above, of aliment ſecreted from the vegetable blood, and laid up in reſervoirs for the future ſuſtenance of their embryon or infant progeny; which reſervoirs are plundered by locomotive animals, and devoured along with the progeny, they were deſigned to ſupport! add to this, that the ſtronger locomotive animals devour the weaker ones without mercy. Such is the condition of organic nature! whoſe firſt law might be expreſſed in the words, " Eat or be eaten!" and which would ſeem to be one great ſlaughter-houſe, one univerſal ſcene of rapacity and injuſtice!

1. Where ſhall we find a benevolent idea to conſole us amid ſo much apparent miſery?—I hope the ſympathizing reader will not think the following account of the happineſs, which organized beings acquire from irritation only, impertinently inſerted in this place; their happineſs derived from imagination and volition may be treated of in ſome future work.

It may firſt be obſerved, that the ſeeds of plants and the eggs of animals, when they have left the pericarp or uterus, and have not yet commenced their new growth upon the ſoil, or beneath the wings of the mother, exiſt in a torpid ſtate, not poſſeſſed of ſenſitive life; and cannot therefore at this time be ſuppoſed to ſuffer pain, when they are deſtroyed by other animals; though thoſe animals obtain pleaſure from the activity, into which their vaſcular ſyſtems are excited by the ſtimulus of the aliment thus ſupplied.

Secondly, that the young of lacteſcent animals both acquire and communicate pleaſure to the enamoured mother, from whom they

receive

receive their nutriment, as mentioned in Botanic Garden, Vol. I. Canto I. l. 278, note; which conftitutes the moft beautiful and moft benevolent part of the great fyftem of nature.

Thirdly, all animals, and, I fuppofe, vegetables, receive pleafure in the reproduction of their fpecies; and where feeds are difperfed on the foil, and the eggs of fome animals and of many infects are buried beneath it, to be revived and hatched by the warmth of the fun; there can be no pain in thefe cafes inflicted on the mother, when they are deftroyed by animals or by infects, as fhe is unconfcious of their deftruction.

Fourthly, as all animal exiftence muft perifh in procefs of time, by the inirritability and confequent debility occafioned by the repetition of ftimulus, which is termed habit, and appears to be an univerfal law of nature: it is fo ordered, that as foon as any organized being becomes lefs irritable and lefs fenfible, and in confequence feeble or fickly, that it is deftroyed and eaten by other more irritable and more fenfible, and in confequence more vigorous organized beings; as infects attack the weaker vegetable productions in preference to the healthy ones; and beafts of prey more eafily catch and conquer the aged and infirm, and the young ones are defended by their parents. By this contrivance more pleafureable fenfation exifts in the world, as the organized matter is taken from a ftate of lefs irritability and lefs fenfibility, and converted into a ftate of greater; that is in other words, that the old organizations, whether ftationary or locomotive ones, are tranfmigrated into young ones: whence it happened, that before mankind introduced rational fociety, and conquered the favage world, old age was unknown on earth!

Finally, the aged and infirm, from their prefent ftate of inirritability and infenfibility, lofe their lives with lefs pain, and which ceafes inftantly with the ftroke of death; infomuch that death cannot fo properly be called pofitive evil, as the termination of good.

To

To this ſhould be added, that a long continued or a great exceſs of pain cannot afflict an organized being; as ſyncope or ſudden death, and conſequent decompoſition, attends very violent pains; and a lingering death attends the continuation of leſs violent ones. Hence it becomes a conſoling circumſtance, that miſery is not immortal.

A philoſopher, whom I left in my library, has peruſed the above paragraphs, and added the ſubſequent one to my manuſcript. "It conſoles me to find, as I contemplate with you the whole of organized nature, that it is not in the power of any one perſonage, whether ſtateſman or hero, to produce by his ill-employed activity ſo much miſery, as might have been ſuppoſed. Thus, if a Ruſſian army, in theſe inſane times, after having endured a laborious march of many hundred miles, is deſtroyed by a French army in defence of their republic, what has happened? Forty thouſand human creatures dragged from their homes and their connexions ceaſe to exiſt, and have manured the earth; but the quantity of organized matter, of which they were compoſed, preſently revives in the forms of millions of microſcopic animals, vegetables, and inſects, and afterwards of quadrupeds and men; the ſum of whoſe happineſs is perhaps much greater than that of the haraſſed ſoldiers, by whoſe deſtruction they have gained their exiſtence!—Is not this a conſoling idea to a mind of univerſal ſympathy?

"I well remember to have heard an ingenious agricultor boaſt, that he had drained two hundred acres of moraſſy land, on which he now was able to feed a hundred oxen; and added, 'is not that a meritorious thing?' 'True,' replied one of the company, 'but you forget, that you have deſtroyed a thouſand free republics of ants, and ten thouſand rational frogs, beſides innumerable aquatic inſects, and aquatic vegetables.'

"Having written the above, I fear you may think me a miſanthrope, but I aſſure you a contrary ſenſation dwells in my boſom;

and though I commiferate the evils of all organic being, Homo fum, humani nihil a me alienum puto."

2. The vafcular fyftems of animal bodies are excited into action by the ftimulus of the fluids, which they abforb, circulate, and fecrete; and when this action is exerted in its natural or moft ufual quantity, it is attended with agreeable fenfation, which conftitutes the pleafure of organized exiftence. Thefe vafcular actions of animals, which perform digeftion, fanguification, and fecretion, convert the aliment, after its folution in the ftomach, into more compounded and more folid materials; as into mufcles, membranes, nerves, bones, and fhells; at the fame time that pleafurable fenfation attends this activity of the fyftem. The vafcular actions of vegetables, which perform their digeftion, fanguification, and fecretion, convert the elements of air and water, or other aliments, which they receive from organized matter decompofing beneath the foil, into more compounded or more folid materials, as into vegetable veffels, mufcles, membranes, nerves, and ligneous fibres; and a degree of pleafureable fenfation muft be fuppofed from the ftrongeft analogy to attend this activity of their fyftems.

3. Many of the materials, which have been thus produced by the digeftion and fecretion of organized beings, and have given pleafure in their production, have been flow in their decompofition after the death of the creature; as the fhells of fifh were originally thus formed, and were left at the bottom of the ocean, till they became wonderfully accumulated, were afterwards elevated by fubmarine fires, and conftitute at this day the immenfe rocks and unmeafured ftrata of limeftone, chalk, and marble. As mentioned in Sect. X. 10. 1.

The ftrata, which are incumbent on the calcareous ones, which confift of coals, fand, iron, clay, and marl, are all of them believed to have been originally the products chiefly of vegetable organization; whatever changes they have fince undergone in the long

progrefs

progrefs of their decompofition, and that all thofe folid parts of the earth have been thus fabricated from their fimpler elements by vegetable and by animal life, and have given pleafure to thofe organized beings, which formed them, at the time of their production.

We hence acquire this fublime and interefting idea ; that all the calcareous mountains in the world, and all the ftrata of clay, coal, marl, fand, and iron, which are incumbent on them, are MONUMENTS OF THE PAST FELICITY OF ORGANIZED NATURE!—AND CONSEQUENTLY OF THE BENEVOLENCE OF THE DEITY!

VIII. *The Cultivation of Brocoli.*

Tranflated in part from an elegant Latin poem of Edward Tighe, Efq.

THERE are of learned tafte, who ftill prefer
Cos-lettuce, tarragon, and cucumber;
There are, who ftill with equal praifes yoke
Young peas, afparagus, and artichoke;
Beaux there are ftill with lamb and fpinach nurs'd,
And clowns eat beans and bacon, till they burft.
This boon I afk of Fate, where'er I dine,
O, be the Proteus-form of cabbage mine!—
Cale, colewort, cauliflower, or foft and clear
If BROCOLI delight thy nicer ear,
Give, rural Mufe! the culture and the name
In verfe immortal to the rolls of Fame.
When the bright Bull afcending firft adorns
The Spring's fair forehead with his golden horns;

When the bright Bull, 19th of April.

Italian

Italian ſeeds with parſimonious hand
The watchful Gardener ſcatters o'er his land;
Quick moves the rake, with iron teeth divides
The yielding glebe, the living treaſure hides;
O'er the ſmooth ſoil, with horrent thorns beſet,
Swells in the breeze the undulating net;
Bright ſhells and feathers dance on twiſting ſtrings,
And the ſcar'd Finch retreats on rapid wings.
Next when the Twins their lucid forms diſplay,
And hand in hand ſalute the lord of day;
When climbs the Crab the blue ethereal plain,
Or ſhakes the Lion his refulgent mane;
Each paſſing month renew the grateful toil,
Upturn with ſhining blade the fertile ſoil;
New ſeeds inſert, whoſe vegetable birth
May riſe ſucceſſive from the womb of earth.
So ſhall hibernal hours on frozen wing
View the green products of the breezy ſpring;
Admiring nymphs the genial banquet ſhare,
Smile on thy labours, and reward thy care.
But when three leaves the young Aſpirer ſhoots,
To other ſoils tranſplant the ſhorten'd roots;
Where no tall branches form a vaulted glade,
Nor ivy'd tower projects a length of ſhade;
There in wide ranks thy verdant realms divide,
Parting each opening file a martial ſtride.
There with charm'd words of ſome poetic ſpell
Call the blue Naiads from their ſecret cell;
From ſilver urns in lucid circles pour
Round each weak ſtem the ſalutary ſhower.
Pants thy young heart to graſp the laurel'd prize,
And ſwell thy Brocoli to gigantic ſize?—

The Twins, 20th of May. *The Crab*, 20th of June.
The Lion, 22d of July.

Soon as each head with youthful grace receives
The verdant curls of ſix unfolding leaves;
O, ſtill tranſplant them on each drizzly morn,
Oft as the moon relights her waining horn;
Till her bright veſt the ſtar-clad Virgin trails,
Or corn-crown'd Autumn lifts his golden ſcales.
Then ply the ſhining hoe with artful toil,
Ere the grey night-froſt binds the ſtiffen'd ſoil;
And, as o'er heaven the riſing Scorpion crawls,
Surround the ſhuddering ſtems with earthen walls.
So ſhall each plant erect its leafy form,
Unſhook by Autumn's equinoxial ſtorm;
And round and ſmooth, with ſilvery veins emboſs'd,
Repel the dew-drops, and evade the froſt.
Thus on the Stoic's round and poliſh'd brows
Her venom'd ſhafts in vain misfortune throws;
By virtue arm'd, he braves the tented field,
The innocuous arrows tinkling on his ſhield.
Hence when aſcendant rules the watery Star,
Or the celeſtial Fiſhes ſwim in air,
Thy guarded ſtalks ſhall lift their curled heads,
And fringed foliage ſhade thy ample beds,
Gem with bright emerald Winter's trackleſs ſnows,
Or bind with leafy wreaths his icy brows.
When leads the Spring amid her budding groves
The laughing graces, and the quiver'd loves;
Again the Bull ſhall ſhake his radiant hair
O'er the rich product of his early care;

The ſtar-clad Virgin, 22d of Auguſt. *Golden ſcales*, 22d of September.

Scorpion, 22d of October. *Evade the froſt.* One advantage, which vegetables receive by repelling the water by the upper ſurfaces of their leaves, is, that it may not incommode their reſpiration; but another is, that by not being thus moiſtened they are leſs injured by froſt.

Watery Star, 19th January. *Celeſtial Fiſhes*, 17th February. *The Bull*, 19th April.

With

With hanging lip and longing eye ſhall move,
And Envy dwell in yon blue fields above.—
  Oft in each month, poetic Tighe! be thine
To diſh green Brocoli with ſavory chine;
Oft down thy tuneful throat be thine to cram
The ſnow-white cauliflower with fowl and ham!—
——Nor envy thou, with ſuch rich viands bleſt,
The pye of Perigord, or Swallow's neſt.

The pye of Perigord was made of the red-legged partridges before the French revolution; and was ſold in London at the price of a guinea for each bird it contained.

Swallow's neſt. There is a ſpecies of ſwallow, that builds a neſt on the banks of the Nile and Ganges, which conſiſts of iſinglaſs; which the bird collects from putrid fiſh left on the ſands; and which is eſteemed a great delicacy, and enters the moſt coſtly ſoups at the luxurious tables of the eaſt.

SECT. XX.

PLAN FOR DISPOSING PART OF THE VEGETABLE SYSTEM OF LINNEUS INTO MORE NATURAL CLASSES AND ORDERS.

I. *The claſſes of plants diſtinguiſhed by the proportion or ſituation of the ſtamina are more natural than thoſe diſtinguiſhed by their numbers. Many Linnean claſſes thus diſtinguiſhed. Many of the orders are natural claſſifications. Uſe of natural claſſes.* 2. *The ſituation and proportion of the ſexual organs are leſs liable to variation than their numbers. Great variation in reſpect to number of the ſtamina. From luxuriant growth. Some ſpecies have but half the number. Others have part of them without anthers. The number of piſtilla varies in different ſpecies of the ſame genus. Progreſs of nature to greater perfection. Of the claſs Syngeneſia.* 3. *Immutable parts diſcovered by reaſoning as well as by obſervation. Filaments of Meadia unchangeable, and of hemerocalis fulva, nigella, collinſonia, ſpartium.* 4. *Some natural orders might become claſſes. As the graſſes, and the umbellatæ, and ſtellatæ. Forms of the filaments, and of the anthers, as well as their ſituations, leſs variable than their numbers.* 5. *Claſſic characters. From ſhort and long filaments. From their unequal heights. From their different inſertions. From their reſpective ſituations. From their adheſions to each other. Or to the corol, or ſtyle. From their exiſtence in different flowers. From the connexion of the anthers, or from the forms of the filaments and anthers.* 6. *Uncertainty of the number of piſtilla. Their proportions and figures leſs variable. And would define more natural orders.* 7. *Characters of orders from the length of the ſtyle. The curvature of it. The attitudes of it. Diviſions of the ſtigma. Abſence of the ſtigma. Adheſions of the ſtyle.* 8. *Concluſion.*

I. OFTEN as I have admired the claſſification of vegetables by the great Linneus deduced from their ſexual organs of reproduction, ſome

ſome of the claſſes have appeared to me to be more excellent than others, as they ſeemed to approach nearer to natural ones. On further attention to this ſubject, I perceived that thoſe claſſes, which were deduced from the proportions or ſituations of the ſtamina, or which included the number of the ſtamina along with their proportions and ſituations, were more natural claſſes than thoſe, which were diſtinguiſhed ſimply by the number of them.

Thus the claſſes termed Dydynamia and Tetradynamia, which are derived from the proportions and ſituations of the ſtamina as well as their number, are wonderfully natural; to which may be added the claſſes Icoſandria, and Polyandria, as their diagnoſtic character conſiſts in the ſituation of the ſtamina on the calyx or petals in the former claſs, and on the receptacle in the latter, though the names of theſe claſſes are not ſo happy, as they ſimply refer to their numbers, which are unfortunately very variable.

Some other of the Linnean claſſes are diſtinguiſhed by the ſituation of the filaments, as the Monadelphia, Diadelphia, Polyadelphia, and Gynandria; all which approach towards natural claſſes; and the Syngeneſia, which is diſtinguiſhed by the adheſion of the anthers, is a claſs beautifully natural, except the laſt order.

Many of the orders alſo in the ſexual ſyſtem are natural claſſifications, as the graſſes in the claſs Triandria, the umbellated plants in the claſs Pentandria, and perhaps the cruciform plants in the claſs Tetandria; with many amongſt thoſe which are termed natural orders at the end of the Genera Plantarum; all which might probably be diſcriminated by ſome ſituation, or proportion, or form, of their reſpective ſtamina.

As the claſſes deduced from the proportions or ſituations of the ſtamina alone, or conjointly with their reſpective number, appear thus to produce more natural diſtributions of vegetables, than thoſe derived ſimply from their number; it might have been more fortunate for the ſcience of Botany, if the great author of the ſexual ſyſtem

ſyſtem had turned his mind to have claſſed all of them from the proportions, ſituations, and forms of the ſtamina alone, or from theſe conjointly with their number, and to have diſtinguiſhed the orders according to the proportions, ſituations, or forms of the piſtilla alone, or conjointly with their numbers.

The great uſe of diſtributing plants into natural claſſes is not only for the purpoſe of more readily diſtinguiſhing them from each other, and diſcovering their names, but alſo for that of more readily detecting the virtues or uſes of them in diet, medicine, or the arts; as for the purpoſes of dying, tanning, architecture, ſhip-building; which has already been happily experienced in attending to the genera or families of plants, which are all natural diſtributions of them, whence the ſame virtues or qualities generally exiſt among all the ſpecies of the ſame genus, though perhaps in different degrees.

2. But another great advantage would probably occur from deducing the characters of the claſſes of vegetables from the ſituations, proportions, or forms of the ſexual organs rather than from their number; which is, that theſe criterions of the claſſes and orders would be much leſs ſubject to variation.

The variation of the number of ſtamina not only frequently occurs from the too luxuriant growth of many cultivated flowers, or by the duplicature or multiplication of their petals, or nectaries, which is liable much to inconvenience the young botaniſt; but ſeveral of the ſpecies of plants have but half the number of ſtamina, which other ſpecies of the ſame genus poſſeſs. This occurs ſo frequently, that the defect of number is expreſſed as an eſſential character of the ſpecies in many inſtances. Thus the ceraſtium pentandrum, and ſpergula pentranda, diſtinguiſh thoſe ſpecies from the other plants of the genus, which poſſeſs ten ſtamens; ſo tamarix floribus pentandris, tamarix floribus decandris, ſalix floribus diandris, ſalix triandra, ſalix pentandra, valeriana floribus monandris, valeriana floribus diandris, verbena diandra.

So the vernal flowers of the corchorus ſiliquoſus have but four ſtamina, but the autumnal ones have numerous ſtamina. The linum flax of this country has but five perfect ſtamina, and five without anthers on their ſummits; whereas the linum luſitanicum, Portugal flax, poſſeſſes ten complete ones. The verbena, vervain, of our country has four ſtamina, that of Sweden but two; the genus albuca, bignonia catalpa, gratiola, and hemlock-leaved geranium, have only half their filaments crowned with anthers; all which and many others evince the uncertainty of depending on numbers alone for diſtinguiſhing the claſſes of plants.

Nor are the number of piſtilla more certain as a criterion of the orders. Thus there is nigella pentagyna, and nigella decagyna; hypericum floribus pentagynis, trigynis, and digynis, with innumerable other ſimilar inſtances, as mentioned in No. 6 of this Section. Which evince, that great confuſion muſt be occaſioned by a reliance ſimply on the number of the piſtilla for defining the orders of plants.

I contend, that the number of the ſexual organs in flowers is more liable to change by the influence of ſoil or climate, or by the progreſs of time, than their ſituations or proportions, or forms, and might therefore probably be more advantageouſly employed in diſtinguiſhing their claſſes and orders from each other, as well as in rendering them more natural combinations.

This mutability or uncertainty of the number of the organs of reproduction belonging to individual flowers, would ſeem to ariſe from an attempt of all organized beings towards greater perfection. Whence as the ſucceſs of the proceſs of reproduction becomes more certain from the greater perfection of the vegetable being, the organs for the purpoſe of reproduction ſeem to become fewer. Whence ſome flowers have loſt half the ſtamina, and in others the anthers of thoſe ſtamina are yet only deficient, and in others the piſtilla are deficient; all which in proceſs of time may gradually become leſs

numerous,

numerous, or ſeparate themſelves from hermaphrodite flowers into ſexual ones, as in the claſſes of monœcia and diœcia; and all of them finally, after a long proceſs of ages, become of the orders monandria and monogynia of thoſe claſſes; whilſt new kinds of vegetables may begin a ſimilar progreſs from leſs to greater perfection. So in animals, the leſs perfect ſeem to poſſeſs organs for a more numerous reproduction, as fiſh and inſects. Such would ſeem to be the perpetual progreſs of all organized being from leſs to greater perfection exiſting from the beginning of time to the end of it! a power impreſſed on nature by the great Father of all.

Thus in the claſs ſyngeneſia, the tendency of theſe vegetables from more numerous to a more ſimple organization for the purpoſe of reproduction is wonderfully conſpicuous. In the order polygamia æqualis, all the florets are furniſhed with male and female organs. In the order polygamia ſuperflua, the florets in the centre have both male and female organs, thoſe in the circumference have only female ones; and of thoſe ſome have loſt the corol of the floret. In the order polygamia fruſtranea the florets in the centre poſſeſs both male and female organs, but thoſe in the circumference have neither; though at the ſame time the corols of thoſe florets remain. And laſtly, in the order polygamia neceſſaria the central florets are ſimply male florets, and thoſe in the circumference ſimply female ones; and thus approach to the claſs of monœcia, having the male and female organs in ſeparate florets; and may in proceſs of time exiſt in ſeparate flowers, and afterwards in ſeparate plants, like the two ſexes of the more perfect animals. Something ſimilar to this ſeems already to have occurred in the plant phytolacca, of the claſs decandria decagynia; which poſſeſſes one ſpecies with twenty males, another with ten, another with only eight males and eight females, and laſtly one of the claſs diœcia, or two houſes.

3. In many flowers ſome circumſtances of the ſituations or proportions or forms of the filaments or anthers may be ſhewn, by *rea-*

ſoning as well as by obſervation, to be leſs mutable than others; as the ſhortneſs of the filaments of dodecatheon meadia, cyclamen, ſolanum, borago, fuſchia, and others. As mentioned in Botanic Garden, Vol. II. note on Meadia. Thus in the flower of meadia the filaments are exceedingly ſhort compared to the ſtyle, and ſeem to have been in that circumſtance immutable. Whence it became neceſſary, firſt to furniſh them with long anthers, which ſtand pointed towards the diſtant ſtigma apparently endeavouring to reach it. Secondly, it was neceſſary to bend the flower-ſtalks, when the corols open into thoſe graceful curves, which conſtitute the uncommon beauty both of this flower and of the fuſchia; that the ſtigma by hanging down immediately beneath the anthers might thus receive, as it falls, the prolific farina. And that this was the evident deſign of the curvature of the flower-ſtalk appears from its riſing again, and becoming quite erect, as ſoon as the impregnation of the pericarp is accompliſhed. Thirdly, as the flower thus becomes perpendicularly pendent, it was neceſſary to reflect the petals for the purpoſe of admitting light and air to the ſexual organs.

We may reaſon from this ſtructure of the meadia, that all this apparatus of long erect anthers to approach the ſtigma; of bending the flower-ſtalk, that the ſexual organs might become pendulous; and then of reflecting the petals to give light and air; might have all been ſpared, if the filaments alone could have grown as long as the ſtyle; as occurs in moſt other flowers. And that therefore in theſe flowers the filaments are the moſt unchangeable parts of them; and that hence the comparative length of the filaments in reſpect to the ſtyle would afford the moſt immutable mark of their eſſential character, or for the purpoſe of claſſification.

Another apparent inſtance of the great unchangeableneſs of the length of the filaments exiſts in the hemerocallis fulva, tawny day-lily, in which I obſerve the ſtyle is crooked, or bent into a zigzag, about the middle of it, evidently for the purpoſe of ſhortening it,

 that

that the anthers might approach the ftigma ; the ftalk of the flower not being fo flexible as to allow it to become pendent, as in the hemerocallis flava, or yellow day-lily.

In nigella, devil in the bufh, the ftyles are very long compared with the filaments, and bending down their ftigmas over the anthers in curves, give the flower a refemblance to a regal crown ; which need not to have occurred, if the filaments could more eafily have been lengthened.

In collinfonia the two anthers ftand widely diverging on fhort filaments, and the tall capillary ftyle bends its ftigma into contact firft with one of them, and afterwards with the other. In the fpartium fcoparium, common broom, the long ftyle bends round into a circle to accommodate the ftigma to the fhort fet of anthers, which great curvature need not have exifted, if the filaments could more eafily have grown longer. Other inftances of fimilar ftructure are related in Sect. VII. 2. 2. of this work.

It is probable, that fimilar obfervations, and a confequent reafoning on them, might be applied to many other kinds of flowers fo as to detect the moft unchangeable parts of them : but great time, labour, opportunity, and ingenuity, would be required to eftablifh from them the moft invariable and moft natural claffes of vegetation.

4. Many different proportions and fituations and forms of the filaments are enumerated in the Philofophia Botanica of Linnæus ; fome of which might poffibly have become claffical characters, if he had turned his attention to them, and given them adapted names ; as he has done to thofe claffes, which he has derived from the fituations of the fexual organs, as didynamia, tetradynamia, fyngenefia, and others, which approach nearer to natural claffes, and are fubject to lefs variation than the numerical ones.

Some of thofe collections of plants, which Linnæus has termed natural orders, and fome of thofe of Ray, and Tournefort, might perhaps have had names affixed to them, denoting the ſituations or proportions or forms of their ſtamina, and have thus conſtituted natural claſſes in the Linnæan ſyſtem. Thus for example the natural order of graſſes might perhaps have had a name denoting their long capillary filaments. The natural order of graſſes is ſo conſpicuous, as to have ſtruck all beholders; they conſtitute, it is ſaid, nearly a ſixth part of the vegetable kingdom, eſpecially in open countries; the leaves are not eaſily broken by being trampled on, but die in winter, becoming yellow and dry; but what is wonderful, they are ſaid to revive in the ſpring, and become green again. This natural order of plants has been divided into cerealia and gramina, corn and graſſes; which however only differ in reſpect to the ſize of the ſeeds. It is much diſunited by the numerical diſtinctions of the ſexual ſyſtem, as ſome graſſes belong to the claſs monandria, diandria, triandria, and hexandria; and thoſe of the triandria, and hexandria, are either hermaphrodite, or monœcious, or polygamous plants. Of theſe a very curious and extenſive table is given in the Prælectiones in Ordin. Natur. a Giſeke Hamburg. 1792, p. 138.

A great part of the natural order of caryophyllei, in which the number of the ſtamina is very variable, are obſerved by Mr. Milne to have their filaments alternately attached to the claws of the petals and to the receptacle, and might poſſibly have a claſſical denomination from that circumſtance. Botan. Dic. Art. Caryophyllei.

The five ſtamina of the umbellated plants in the claſs of pentandria digynia, with five petals, two ſeeds, above; which are termed umbellatæ in the natural orders of Linnæus; as they diverge from each other, might perhaps be called five ſtarred, or cinque-pointed ſtamina from this ſituation. And in part the natural order of plants termed ſtellatæ by Linnæus, as galium, and aſperula; which belong to the claſs tetandria monogynia with one petal, two berries, above; the four diverging ſtamina, might perhaps be termed cruciform, as they oppoſe each other. And thus theſe natural collections of vegetables might acquire a claſſical denomination from the ſituations of their ſtamina, or perhaps from the form of their filaments or anthers.

To theſe ſituations and proportions of the ſtamina, with many others, might be added the form of the filaments, as capillary, flat, wedgeform, ſpiral, awled; and alſo the forms and ſituations of the anthers, as globular, oblong, arrowy, angular, horned. Which may be ſeen in the Philoſophia Botanica of Linnæus, p. 65; or a tranſlation of them in Miln's Botanical Dictionary, under the titles of filament and anther. All which, I ſuppoſe, are much leſs variable by ſoil or climate, than the numbers of their reſpective ſexual organs, and would in the hands of an ingenious botaniſt form more natural claſſifications.

5. Claſſical characters might perhaps be taken from the length of the filaments compared to that of the ſtyle, with ſome other concomitant circumſtances; as firſt where they are ſomewhat ſhorter than the ſtyle, as in the pendent bell-flowers of lily, fritillaria, campanula. Secondly where the filaments are more than twice as ſhort as the ſtyle, as in meadia, cyclamen, ſolanum, borago, fuſchia. Or thirdly where the filaments are more than twice as long as the ſtyle, and in the natural order of graſſes.

Secondly, the unequal heights of the filaments at the firſt opening of the corol. In many flowers the inferior ſet of ſtamina riſe up to the ſtigma, when the higher ſet have diſcharged their pollen. To theſe ſituations of the ſtamina may alſo be added their number, as in the two very natural claſſes of Linnæus, the didynamia and the tetradynamia. One of theſe might be termed two higher than two; the other four higher than two. To which might perhaps be added a third claſs, of many higher than many; as ſix above ſix in lithrum ſalicaria, five above five in lychnis.

Thirdly, the different inſertions of the filaments, as firſt on the calyx, which principally diſtinguiſhes the claſs icoſandria of Lin-

 næus,

næus, and which thus approaches towards a natural claſs. Secondly on the receptacle, which diſtinguiſhes the claſs polyandria of Linnæus, which alſo approaches toward a natural claſs. And thirdly, the inſertion of the filaments alternately to the claws of the petals, and to the receptacle; which diſtinguiſhes a part of the natural order of the caryophyllei, in which the number of the ſtamina is very various.

Fourthly, the ſituation of the filaments in reſpect to each other; as firſt in the natural order of Linnæus termed ſtellatæ, or a part of the tetrandria monogynia; the diverging filaments oppoſe each other, and might be termed cruciform, as in galium, aſperula. Or ſecondly, where five diverging filaments aſſume the appearance of a ſtar, as in the natural order of umbellatæ, or a part of pentandria digynia, and might have a name borrowed alſo from their number, like five-ſtarred, or cinque-pointed, applied to the filaments, as mentioned above.

Fifthly, the adheſions of the filaments to each other at their baſe. This has given names to three claſſes of the Linnæan ſyſtem, which approach to natural ones, under the term of brotherhoods; as firſt, where the filaments all adhere at their baſe, as in the claſs monadelphia; ſecondly, where they adhere in two ſets, as in the claſs diadelphia; and thirdly, where they adhere in many ſets, as in the claſs polyadelphia.

Sixthly, the adheſions of the filaments to the corol, as where they adhere more than half their length to the internal part of it, as in many monopetalous flowers, as primula, auricula; or where the filament ariſes from the petal, or where the anthers adhere to the margin of the petal, as in many of the natural order of ſcitamineæ, as obſerved in the Prælect. in Ord. Natur. a Giſeke, p. 189.

Seventhly, where the filaments adhere to the ſtyle, as in the claſs gynandria, which approaches to a natural one.

Eighthly, the ſituations of the ſtamina not in the ſame flowers

with

with the piſtillum. This has alſo given names to three claſſes of the Linnæan ſyſtem, monoecia, dioecia, polygamia.

Ninthly, the connexion of the anthers, which has given the name to the claſs ſyngeneſia, which excepting the laſt order, is a wonderfully extenſive and natural claſs.

To theſe varieties of ſituation, proportion, and adheſion, of the filaments, may be added thoſe of the anthers on their ſummits; which to an attentive obſerver may perhaps be as numerous as thoſe of the filaments, and to theſe may again be added the various forms of the filaments, as capillary, flat, wedgeform, ſpiral, feathered, &c. and alſo the various forms of the anthers, as oblong, globular, arrowy, angular, horned. All which are deſcribed in the Philoſophia Botanica. And by an adoption of ſome of theſe ſeparately or in conjunction for claſſical characters, I ſhould hope that new claſſifications might be diſcovered inſtead of thoſe, which are ſimply numerical. Which might be more natural ones, leſs ſubject to variation, eaſier to be diſtinguiſhed from each other, and more ſimilar in their good or bad qualities; and might thus add to the great beauty and utility of the preſent wonderful arrangement of ſo many thouſand vegetables in the Linnæan ſyſtem.

6. The ſame obſervations and mode of reaſoning are applicable to the various orders of the ſexual ſyſtem. Which if the great Linnæus had fortunately deduced them from the proportions, ſituations, or forms of the ſtyles and ſtigmas, the characteriſtic ſigns might have been leſs liable to change by ſoil or climate, and many of the orders have been more natural collections of vegetables, than thoſe are, which he has derived ſimply from their number.

The uncertainty of the number of piſtilla, and the confuſion, which might be occaſioned by a reliance on it, was mentioned in No. 2 of this ſection; there is a nigella pentagyna, and a nigella decagyna; there is an hypericum floribus pentagynis, trigynis, and digynis; and in the whole order of fruſtraneous polygamy in the

the clafs fyngenefia the florets of the ray are furnifhed with a ftyle and no ftigma, as in the funflower.

The flowers of the polygonum, whofe claffical character is octandria, and its order trigynia, affords many inftances of the uncertainty of the number of the fexual organs, both in refpect to the ftamina and piftilla. Thus the fpecies 4, 5, 6, 7, poffefs but five ftamina in each; the fpecies 8, 9, 10, have each of them fix ftamina, and the eleventh fpecies has feven ftamina. And laftly the fpecies 4, 5, 6, 8, 9, 11, 12, have each of them but two piftilla, and all the reft three piftilla.

From thefe and other innumerable inftances there is reafon to conclude, that the proportions, fituations, and forms of the ftyle and ftigma, to which might be added their number conjointly, would have made effential characters for the orders, which would have been lefs variable than thofe derived only from the number of them, and would have rendered them more natural collections.

7. The characters of the orders might be deduced firft from the length of the ftyle compared with that of the filaments; as where the ftyle is more than twice as long as the filaments, as in meadia, cyclamen, folanum, fufchia. Secondly, where the ftyle is about one third longer than the filaments, as in lilium, fritillaria, campanula, and many other bell-flowers. Thirdly, where the ftyle is very fhort compared to the filaments, as in poppies.

2. The characters of the orders might be deduced from the curvatures of the ftyle. As firft, where the ftyle bends into a curve over the anthers to bring the ftigma into contact with them, as in nigella, devil in the bufh. Secondly, where the ftyle bends into a circle like a french-horn to accommodate the ftigma to two fets of ftamina in fucceffion, firft the lower, and then the higher, as in fpartium fcoparium, common broom. Thirdly, where the ftyle is crooked in the middle of it, making a kind of zigzag, to lower the

ftigma

ftigma to the anthers beneath it, as in hemerocallis fulva, tawny day-lily.

3. Characters might be deduced from the attitude of the ftyle; as where it is pendent, that the ftigma may be accommodated to the anthers above it, as in many bell-flowers. Secondly, where it is inclined at a confiderable angle to accommodate the ftigma to the inclined anthers, as in epilobium, willow-herb, and gloriofa fuperba. Thirdly, where the ftyle is erect, to adapt the ftigma to the upright anthers, as in many flowers.

4. Where the divifions of the ftigma expand, and bend down toward the anthers beneath them, as in fome kinds of dianthus, pink, and in epilobium.

5. The total abfence of the ftyle might mark an order.

6. The total abfence of the ftigma, which is a characteriftic mark of the florets of the ray in the order fruftraneous polygamy of the clafs fyngenefia.

7. Where the ftyle adheres to the ftamina, as in the natural order of Linnæus termed calamariæ, as obferved in Philof. Botanica, No. 102, on the Piftilla, p. 68.

8. Where the ftyle fupports the ftamina as in the clafs gynandria.

9. Where the ftyle appears to exift both above and below the germ, as in capparis, euphorbia.

10. The lateral adhefion of the ftyle to the germ, as in one of the natural orders of Linnæus, which he has termed fenticofæ, or briers, which includes the rofe, rafpberry, ftrawberry, agrimony, alchemilla, and many others, which might be named from the lateral adhefion of the ftyle to the germ, which Linnæus afferts to exift both in the natural order above mentioned, and in the order Icofandria polygyna. Philof. Botan. p. 67.

If to thefe proportions or fituations of the ftyle were added the varieties

rieties of its figure, as cylindrical, angular, awled, capillary; and to thefe were again added the divifions of the ftigma, as convolute, revolute, fix-parted, many-parted. And to thefe were again added the various forms of the ftigma, as globular, egged, end-nicked, cruciform, feathery, &c. which are enumerated in the Philofophia Botanica; there is great reafon to believe, that characteriftic marks of all the orders of plants might be deduced and named from fome of thofe circumftances feparately or conjointly; which might diftinguifh them from each other with greater eafe and certainty, and by marks lefs variable by foil or climate, than by the number alone; and by rendering them more natural add to the beauty and utility of the Linnæan fyftem.

Conclufion.

Neverthelefs I am well aware of the great general inconvenience of altering fo extenfive a fyftem once eftablifhed, and am forry to fee fome idle efforts to add the claffes already deduced from fituation or proportion to thofe, which are fimply numerical; and thus rather to deteriorate than to improve the prefent fyftem of the great mafter.

I profefs myfelf incapable to execute the plan, which I have here fuggefted, as it would require a moft exact knowledge of the detail of botany, as well as of the outline; would require many years of unremitted application, with every opportunity of vifiting botanic gardens, or examining dry collections, and infpecting prints and drawings of vegetables; and would demand a genius, which few poffefs, capable of reducing the complex and intricate to the fimple and explicit.

But if the fyftem of the great Linnæus can ever be intrinfically improved, I am perfuaded, that the plan here propofed of ufing the fituations, proportions, or forms, with or without the numbers of the ſexual organs, as criterions of the orders and claſſes, muſt lay the foundation; but that it muſt require a great architect to erect the ſuperſtructure. And my principal deſign in adjoining this imperfect ſketch at the end of this work was to warn thoſe botaniſts, who have began to interweave ſome of the Linnæan claſſes deduced from ſituation or proportion of the ſexual organs into thoſe diſtinguiſhed ſimply by number, that they ſo far contribute to deteriority the great ſyſtem, which they mean to amend.—At the ſame time I much applaud, and beg leave to recommend to the attention of the public, the ſuperb pictoreſque botanical coloured plates now publiſhing by Dr. THORNTON, which I ſuppoſe have no equal.

ADDITIONAL NOTES.

1. *To be inserted before the laſt paragraph of Sect.* IV. 2. 1. *at p.* 45, *line* 22.

In the preſent year 1799, Auguſt 18, there was an uncommon ſummer-flood on the Derwent, which covered my garden above three feet deep with muddy water. Many plants of the rheum hybridum, mule rhubarb, which were tranſplanted in the ſpring, and had not flowered, had their large pointed leaves covered with mud, ſo as to render the green colour totally inviſible after the water ſubſided. They appeared ſtrong as before for a day or two, and then every one withered and dropped down. The ſame happened to the leaves of many other vegetables, and to eſpallier apple-trees, as high as they were immerſed; which was doubtleſs owing to their reſpiration being precluded by the veil over them of a fine tenacious mud. See Sect. VII. 2. 6.

2. *To be inserted in Sect.* VII. 2. 6. *at p.* 115, *after line* 23.

The rheum hybridum, mule rhubarb, deſcribed in Murray's Syſtema Vegetabilium, edition the fourteenth, I believe to be produced between the palmated rhubarb, and the common rhubarb of our gardens, or rheum rhaphonticum; as it appeared both in my garden

and

and my neighbours amongſt a mixture of thoſe two kinds of rhubarb, without being previouſly placed or ſown there. The leaf is very large and pointed, without being palmated, and is a week or two forwarder in the ſpring than either of the other rhubarbs, and the peeled ſtalks are aſſerted by connoiſſeurs in eating to make the beſt poſſible of all tarts, much ſuperior to thoſe of the palmated or raphontic rhubarb; and are ſo much more valuable as a luxury, as they precede by a month the gooſeberry and early apple; and may be well propagated by dividing the roots, as they do not produce ſeed in all ſummers. See Sect. IV. 2. 1.

3. *To be inſerted at the end of Sect.* X. 4. 9. *p.* 207.

Mr. Ruckert planted two beans in pots of equal ſize filled with garden-mould; the one was watered almoſt daily with diſtilled water, and the other with water impregnated with carbonic acid gas, in the proportion of half a cubic inch to an ounce of water; and both of them were expoſed to all the influence of the atmoſphere except to the rain. The bean treated with the carbonic acid water appeared above ground nine days ſooner than that moiſtened with diſtilled water, and produced twenty-five beans; whereas the other pot produced only fifteen. The ſame experiment was made on ſtock-july flowers, and other plants with equal ſucceſs. An. Chym. 1788.

4. *To be inſerted at the end of Sect.* X. 7. 7. *p.* 228.

Beſides which the vitriolic acid abounding in many clays, when brought into contact with mild calcareous earth, by the various operations of agriculture, muſt unite with it, and ſet at liberty the carbonic acid either in a fluid form, or a gaſſeous form beneath the ſoil;

which is known to be ſo friendly to vegetation, when applied to the roots of plants; and at the ſame time a gypſum will be produced, which is now alſo believed to be uſeful in agriculture.

Mr. Kirwan aſſerts, " That the gypſum uſed with ſucceſs in agriculture is of a fibrous texture; and that clay lands, he believes, to be more improved by it than calcareous ones. The time of ſpreading it is in February or March, and it is then to be thinly ſtrewed on graſs-land at the rate of about eight buſhels to an acre; as more he ſays would be hurtful." He further adds that the theory of its effects is to be deduced from its extraordinary ſceptic power; as it is found to accelerate putrefaction in a higher degree than any other ſubſtance, (Hiſtoire de Putrefaction, p. 36), whence it is not to be ploughed in, but barely to be ſtrewed on the ſurface of the land in the month of February, to convert the old graſs quickly into coal to nouriſh the young growths."

I have tranſcribed the above from Mr. Kirwan's Treatiſe on Manures, but am liable to doubt the experiments concerning bodies promoting putrefaction; as the progreſs of that proceſs has generally been only judged of by the odour; which may poſſibly be altered or deſtroyed by many bodies, by their uniting with it without otherwiſe affecting the tendency to diſſolution. Add to this another circumſtance, ſhewing the uncertainty of theſe deductions, that ſome of theſe antiſeptic materials, as ſea-ſalt, and lime, are ſaid to promote putrefaction, when uſed in ſmall quantities; and to ſuppreſs it, when uſed in large ones.

5. *To be inſerted in Sect.* XIII. 2. 2. *at the end of the paragraph which mentions Mr. Lawrence's letter to Mr. Bradley.*

Another thing, which renders low ſituations leſs proper for gardens, is, that I believe them to be much more liable to be infeſted by by the aphis; as leaves of the nut-trees in my garden on the banks of the Derwent are every year crowded with innumerable aphifes on their inferior furfaces, and yet I have feen few, if any of them, on nut-trees in fome higher fituations, which I happened to infpect. Add to this, that the great honey-dew, mentioned in Sect. XIV. 1. 7. was produced on a row of willows by the fide of water. This may neverthelefs be in part afcribed to fome other local circumftance; as I this year obferved numerous large black aphides round the ftalks of garden-beans on a clayey foil, which did not exift in my garden, which may be called a carbonic foil. Though on the peach and nectarine trees, againft the walls in my low garden, and on fome plum-trees, the aphides exift almoft every year in fuch deftructive multitudes as to prevent the fruit from fucceeding, and thence to render them not worth cultivation; and to render the leaves of the nut-trees lefs in fize, and lefs prolific than other nut-trees on a more elevated and clayey foil, with which I this year compared them.

Why the aphis fhould be fo much more numerous in moift fituations is a curious fubject of inquiry, but is fo fimilar to another animal fact, that they may illuftrate each other. The cough and confequent confumption of fheep, which occurs annually in moift fituations, is owing to an infect called a fleuk-worm, about the fize and fhape of a child's finger-nail, which creeps up the gall-ducts from the inteftines, and preys upon the livers of fheep; as may be feen in moift feafons in our fhambles. This feems to occur from the bile becoming too dilute from fo much watery nourifhment in thofe animals, and that thence it does not poffefs fufficient bitternefs or acrimony to prevent the depredation of thefe infects, as in drier feafons. On the fame account I fufpect the juices of nut-trees and of willows planted in very moift fituations may be rendered too dilute; but that in higher fituations they may poffefs fufficient acrimony or bitternefs mixed with the fap-juice to prevent the depredations of the aphis. See Sect. XIV. 2. 8.

6. *To*

6. *To be inserted at the end of Sect.* X. 5. 3.

Phoſphorated lime is ſaid to be found in the greateſt quantity in wheat, where it contributes to the formation of the gluten, which is thence not improperly denominated by ſome writers animal gluten; which in rainy years has been obſerved by Witwer to be in ſmaller quantity Diſſert. II. p. 103. Hence the uſe of bone-aſhes as a manure for wheat, as obſerved by Mr. Kirwan. Eſſay on Manures, p. 53.

7. *To be inserted at the end of Sect.* VI. 10.

Beſides the various ſecretions above deſcribed Brugmanns is ſaid by Humbolt to have ſhewn, that plants void an excrement like animals, which might be noxious to them, if retained; that he put the plant, lolium, ray-graſs, into a glaſs of water, and obſerved daily at the extremities of the roots a ſmall drop of a viſcous material; which he detached and found to be renewed on the next day. But this I ſuſpect to have been produced by the death and conſequent decompoſition of the extremities of the roots in their unnatural ſituation. Journ. de Phyſique Delametherie, T. IV. p. 388.

8. *To be inserted at the end of Sect.* XIV. 4. 2.

In the Tranſactions of the American Philoſophical Society there is a paper ſhewing, that the water-rats of that part of the country are ſo liable to be affected with tape-worm, as is ſuppoſed much to diminiſh their numbers. In this country many animals, as I believe dogs, cats, and geeſe, as well as the human ſpecies, are afflicted with this inteſtine enemy. Could ſome of theſe diſeaſed American rats be imported into this country, and propagate their malady amongſt the native rats of this climate ?

9. *To be inſerted at the end of Sect.* X. 7. 8. *p.* 228.

Having now ſpoken of carbon, of lime, and of clay, which with ſiliceous ſand conſtitute the principal ingredients of fertile ſoils, ſome rules may be required for diſtinguiſhing the goodneſs of ſoils by the purchaſer, as well as by the poſſeſſor. For this purpoſe the chemical analyſis would firſt preſent itſelf, as attempted by Fordyce, many years ago, and lately by Giobert, Bergmen, Kirwan, and others.

M. Giobert found, that one pound of a fertile ſoil in the vicinity of Turin contained of carbonic matter, which would burn and flame, about twenty-five grains, of flinty ſand about 4400 grains, of clay about 600 grains, of lime about 400 grains, and laſtly, of water about 70 grains. The ſame author found that one pound of ſome barren ſoils was compoſed of ſiliceous earth about 3000 grains, of argillaceous earth about 600 grains, and of calcareous earth about 400 grains, and I ſuppoſe without any carbonic matter.

Mr. Kirwan ingeniouſly obſerves, that the quantity of moiſture, which ſome countries are more liable to than others, ſhould be nicely attended to, at the ſame time that you eſtimate the fertility of land by its analyſis, as moiſt climates or ſituations may require more ſand than drier ones; and therefore the ſame component parts of ſoil would not be the moſt fertile, on both the weſtern and eaſtern coaſts of this iſland ; as the former experiences more rain than the latter ; nor on the ſummit, declivity, and baſe of moſt mountains, which differ in their degree of moiſture.

It appears from hence, that the chemical analyſis of ſoils is not yet arrived at ſufficient accuracy to be depended upon with certainty to diſcover their degrees of fertility. But as the carbonic part of ſoil probably

probably contributes moſt to the growth of vegetables, and next to that the calcareous part; there is reaſon to conclude, that if a few pounds of different ſoils are dried by the ſame degree of heat, and then weighed, and afterwards expoſed to a red heat in an open fire; that the ſoil, which loſes moſt weight, is probably the moſt fertile; becauſe the carbonic matter will almoſt all eſcape in flame, and almoſt half the weight of the calcareous earth in carbonic acid.

Another method of giving ſome conjecture concerning the fertility of a ſoil may be by examining its ſpecific gravity; as the ſpecific gravity of garden-mould is ſaid by Muſchenbroek to be 1,630, compared to 1,000 of water. And Fabroni found the ſpecific gravity of barren ſandy land to be 2,210 to 1,000 of water. This experiment would not be difficult to try with ſufficient accuracy by drying two different ſoils at an equal diſtance from a fire, or in the ſame oven, and then weighing a pound of each in a thin bladder with apertures near its top or neck; and then letting the bladder ſink ſo low into water, as to admit the water through the apertures amongſt the ſoil; and laſtly, obſerving the difference between their reſpective weights in air, and in water.

Nevertheleſs the method moſt in uſe by the purchaſers of land to judge of its value is by attending to the growth and colour of the vegetables, which cover it; which requires an experienced eye, and cannot be eaſily deſcribed in words. Add to this that vegetables, which grow wild on ſoils, will in ſome meaſure indicate the nature of them. As the digitalis, and arenarea, are found generally on ſandy ſoils, the veronica becabunga, and creſſes of ſome kinds, belong to moiſt ſituations, and others to mountainous ones. A particular catalogue of ſuch plants, as ſpontaneouſly grow in different ſituations, might aſſiſt in diſcovering the degree of fertility, and the nature of the ſoil; as other flowers by the time of their opening in each climate, which is termed the Calendar of Flora, may teach the temperature of the ſeaſon.

In ſome parts of the country the ſpontaneous production of many docks, rumex, has been reckoned the mark of an inferior ſoil, and the production of thiſtles, ſerratula arvenſis, to be a ſign of a good one; which explains a ſtory in a black letter book on huſbandry, which ſays, "A blind man went to purchaſe a farm, which was offered to ſale, and riding over the paſture land, and hearing the goodneſs of the ſoil much applauded by the poſſeſſor, at length diſmounted, and ſaid to his ſervant, 'Tie my horſe to a thiſtle!' 'Here are no thiſtles,' replies the ſervant, 'but I can tie him to a dock.' 'Then I will not purchaſe the land,' ſays he, and mounting his horſe with a good morning to you, Sir, left the owner of the eſtate in great ſurpriſe."

10. *To be inſerted at the end of Sect.* XV. 3. 7.

To diſcover when the ſeeds of herbaceous plants are ripe, as of wheat, the dryneſs or ſtraw-colour of the ſtem is in general a good criterion; as when the ſtem dies, and becomes bleached by the oxygen of the atmoſphere, no more nutriment can be conveyed to the mature ſeed. And to determine at what time to collect thoſe fruits, which never ripen on the trees in this climate, as crab-apples, and baking-pears, change of colour or fall of the leaf ſhews, that they can acquire no more nouriſhment, and may receive injury from the approaching froſt.

But to determine when our beſt or earlieſt apples and pears are ripe enough to gather, that is, when they will acquire no more nutriment from the tree, depends on a very curious circumſtance of the colour of the ſkin of the ſeeds. During the infant ſtate of the ſeed there is no cavity round them; but the ſeed is in contact with the ſeed-veſſel, as may be ſeen on cutting an unripe pear or apple; and the ſeed therefore is perfectly etiolated, as it cannot part with any of its oxygen. Afterwards when there is no more depoſition of nutritious

tious matter to enlarge the fruit, the cells, in which the feeds are contained, become hollow, producing an air-veffel for the living embryon; of what purity the air may be, which is produced in thefe cells, has not I believe been tried, and may differ as the embryon-feed grows older; but the oxygen, which it contains, feems to have been difengaged from the membranes, which cover the feeds, which thence become coloured; whence the dark colour of the feeds of apples and pears is a proper criterion of the time, when they fhould be gathered; as it indicates, that the fruit will no longer increafe in fize, as it now waftes and becomes hollow by abforbing fome of the mucilage from the central parts of it.

11. *To be inferted at the end of Sect.* VI. 5. 5.

Sugar is not only afforded by the fap-flow of trees, as the maple, birch, and vine, but alfo I fuppofe from that of herbaceous vegetables, as heracleum fpondilium, cow parfnip, and ferratula arvenfis, field thiftle; when the former of thefe plants has been cut off near the ground in the vernal months, the fap-juice from the ftump I have obferved to flow in fuch quantity for many days, that I have doubted whether by a proper apparatus for catching it the plant might not be advantageoufly cultivated for the purpofe of making wine, or of extracting the fugar as from the maple of America. This circumftance has been faid to fhew a proper time for deftroying the weeds, as if they be mowed in the bleeding feafon, they are believed to perifh by the lofs of fap-juice.

As all fpirit is the fame, when nicely diftilled, whether it be found in wine, ale, cyder, brandy, rum, gin, and is the product of fugar by the chemical procefs of fermentation; and as all fugar is the fame, when nicely cleaned, whether it be obtained from fruits, grains, roots, canes, or fap-juice; there is reafon to believe, that fugar as well as ſpirit may ſome time or other be economically procured from the vegetables of this climate, as Margraff extracted it from the beet-root, and from potatoes. For the ſtrength of common ale, which is produced from the ſugar contained in malt, is ſaid to be about the ſame as that of ſome domeſtic wines, which owe their ſpirit to prepared ſugar. And as in the former a buſhel or ſtrike of malt is uſed to about ſix gallons of water, and in the latter about twenty pounds of ſugar to ſix gallons of water, it follows, that one ſtrike of malt contains about twenty pounds of ſugar; which if an eaſy method of cleaning it from the mucilage and from the eſſential oil of the ſeed could be diſcovered, it may ſome time be manufactured at home cheaper, than it can be procured from abroad.

We may add, as all ſugar is the ſame, and all ſpirit is the ſame, from whatever plant they are procured; that the flavours of wines differ from each other ſolely in the eſſential oil, which they contain, or the quantity of acidity, or of ſugar not yet fermented; and that in reſpect to wholeſomeneſs wines only differ from each other in their ſtrength or quantity of ſpirit, unleſs where ſome noxious material has been uſed to fine them, or to counteract their tendency to the acetous fermentation, as lead has been employed in ſome of the cyders of our country, and in ſome of the white wines of France, to correct their acidity; and it is ſaid that arſenic is occaſionally employed for the purpoſe of fining white wines.

The injurious methods of fining wines, and of ſtopping their tendency to acidity having been mentioned, the innocuous ones ought to be ſubjoined; for the former it has been propoſed to filter muddy wine through fine ſand laid on a ſieve; but this I am told does not ſucceed, as the mucilage of the foul wine ſoon fills up the interſtices of the grain of ſands; but that an efficacious method is to ſhower the fine ſand on the wine through a ſieve; which as it paſſes down by its own weight will carry the mucilaginous mud of the wine along with it. And laſtly, if ſome colouring particles cannot thus be made

made to ſubſide, a little more ſimple mucilage muſt be added, as gum arabic or whites of eggs, and a ſand-ſhower be again paſſed through it.

In reſpect to the tendency of wines to become vinegar, this I am informed may be prevented by not expoſing the fermenting material to the air more than can be eaſily prevented, as it is the union of the oxygen of the atmoſphere with the ſpirit that converts it into vinegar; and though the vinous fermentation proceeds ſlower, when ſecluded from the air, yet it finally becomes more perfect; as the ſugar in ſweet wines continues to become ſpirit, after it is corked up in bottles, though the proceſs is ſlower, and the wine conſequently becomes ſtronger as it grows older, and the ſweetneſs vaniſhes.

Hence I obſerve the manufacturers of raiſin-wines ſet them to ferment in large caſks with only the bung-hole open, that they may not be too much expoſed to the atmoſphere; and ſoon ſtop them up or bottle them, before the ſweetneſs vaniſhes, which they judge of by the taſte.

I was once told by a gentleman, who made a conſiderable quantity of cyder on his own eſtate, that he had procured veſſels of ſtronger conſtruction than uſual, and that he directed the apple-juice, as ſoon as it had ſettled, to be bunged up cloſe; and that though he had had one veſſel or two occaſionally burſt by the expanſion of the fermenting liquor, yet that this rarely occurred, and that his cyder never failed to be of the moſt excellent quality, and took a conſiderably greater price at market.

Nor ſhould this account of fermentation be concluded without obſerving, that it converts ſugar, which is a wholeſome nutriment both to young and old, into ſpirit, which is a poiſonous material to all; as it ſtimulates the whole ſyſtem into too violent exertion for a few hours, and leaves it afterwards in conſequence torpid and inactive; and hence that the ſtrongeſt wines are the moſt pernicious, and that all of them ſhould be diluted with water. As thoſe in general, who drink

drink ale to excefs, acquire the gravel; thofe, who drink wine to excefs, acquire the gout; and the drinkers of fpirits die of the dropfy!—but it is the cuftom of moft of the inebriates of this country to begin their unfortunate career with the firft, and terminate it with the laft.

12. *To be inferted at the end of Sect.* X. 6. 8.

An important paper concerning lime is this year publifhed in the Philofophical Tranfactions by Mr. Tennant, who having been informed, that two kinds of lime were ufed in agriculture, which differed greatly in their effects, one of which it was neceffary to ufe fparingly, and to fpread very evenly over the land; for it was faid, that a large proportion of it diminifhed the fertility of the foil; and that wherever a heap of it had been left on one fpot, all vegetation was prevented for many years. And that of this kind of lime fifty or fixty bufhels on an acre were as much as could be ufed with advantage; while of the other fort of lime a large quantity was never found to be injurious; and that the fpots, which were entirely covered with it, became remarkably fertile, inftead of being rendered barren.

Mr. Tennant having analyfed thofe two kinds of lime found, that the latter confifted folely of calcareous earth; but that the former contained two parts of magnefia with three parts of calcareous earth. He afterwards obferved, that though vegetable feeds would grow equally well in both thefe kinds of limeftone, when fimply reduced to powder; yet that, when they were calcined fo as to become lime, and both of them ftrewed about the tenth of an inch thick on garden mould, that the magnefian lime prevented nearly all the feeds, which had been fowed, from coming up; while no injury was occafioned by the calcareous lime ufed in the fame manner.

This important difcovery feems to explain the caufe of fuch variety of opinion about the ufe of lime, which fome have believed to be of

no

no advantage, and even injurious to land; which has probably been owing to their having ufed the magnefian lime, and having laid on too much of it.

Mr. Tennant firft found magnefian lime near the town of Doncafter, and afterwards at York, at Matlock in Derbyfhire, and at Breeden in Leicefterfhire, and at Workfop in Nottinghamfhire. He obferves, that the cathedral and walls of York are built with this magnefian limeftone; and that at Matlock the magnefian and calcareous limeftones are contiguous to each other; the rocks on the fide of the river Derwent, where the houfes are built, being magnefian, and on the other fide calcareous. He obferved alfo here, that the magnefian limeftone was incumbent on the calcareous; for in defcending into a cave formed in that rock, he found a feparate vein of calcareous limeftone, which was full of fhells, but contained no magnefia; and obferves in general, that magnefian limeftone may be readily diftinguifhed from the calcareous by its fo much flower folution in acids, and that it contains generally very few fhells, but that thofe alfo are impregnated with magnefia.

As all limeftone may be divided into three kinds; the rocks, which remain, where they were formed from fhells beneath the ocean, except that they were afterwards elevated by fubmarine fires; and fecondly into alluvial limeftone, as thofe which have been diffolved in water, and fimply precipitated, as the beds of chalk, which contain only the moft infoluble remains of fea-animals, as the teeth of fharks; and thirdly thofe which after having been diffolved and precipitated, have been long agitated beneath the fea, till the particles have been rolled fo againft each other, as to acquire a globular form, which is faid to refemble the roe, or fpawn, of fifh, and which contain very few fhells or none, as the Ketton ftone, and that which I have feen on Lincoln Heath extending almoft from Sleaford to Lincoln.

Now as the falts of the fea confift of only two kinds, common falt, ſalt, or muriate of ſoda, and vitriolated magneſia, commonly called Epſom ſalt, which in the ſea-waters ſurrounding this iſland were found at a medium to exiſt in the proportion of one thirtieth part of common ſalt, and one eightieth part of vitriolated magneſia compared to the quantity of water. And ſecondly as theſe ſalts are believed by many philoſophers to have been formed by vegetable and animal matters, which principally grew upon the ſurface of the dry land, after it was raiſed out of the primeval ocean; and that in conſequence the ſaltneſs of the ſea was poſterior to the formation of the primeval rocks of limeſtone; and from hence we underſtand, why thoſe limeſtone ſtrata, which have not been diſſolved or waſhed in ſea-water ſince the ſea became ſalt, are not mixed with magneſia.

The chalk muſt have been diſſolved and precipitated from water, as it exactly reſembles the internal part of ſome calcareous ſtalactites, which I have in my poſſeſſion; yet there is no appearance of its component particles having been rubbed together into ſmall globules, and may not therefore have been removed from the ſituation, where it was produced, except by its elevation above the ſurface of the ocean.

But that alluvial limeſtone, which conſiſts of ſmall globules adhering together, called Ketton limeſtone, and of which there appears to be a bed ten miles broad from Beckingham to Sleaford in Lincolnſhire, and twenty miles long from Sleaford to Lincoln, I ſuſpect may probably conſiſt of magneſian limeſtone; which is alſo ſaid in that country to do no ſervice to vegetation; for this alluvial limeſtone by having evidently been long rolled together beneath the ſea, by which the ſmall cryſtalliſed parts of it have had their angles rubbed off, is moſt likely to have thus been mixed with the magneſia of the ſea-water, which is ſaid to contain one eightieth part of its weight of vitriolated magneſia, as above mentioned.

At the lime-works at Ticknal near Derby there appears a ſtratum of of alluvial limeſtone, like Ketton limeſtone, which they do not burn for ſale, over the bed of the calcareous limeſtone, which they get from beneath the former, and calcine for ſale. It is probable, that the ſuperior bed may contain magneſia, which has rendered it not ſo uſeful in agriculture.

It is more probable, that alluvial limeſtone has acquired its mixture of magneſia from the ſea-water; as magneſia in its uncalcined ſtate will precipitate lime from water, as obſerved by Dr. Alſton; who thence propoſes to render water pure and potable, which has been long kept at ſea free from putridity by having lime mixed with it, by precipitating the lime by the addition of mild magneſia; which is a ſubject now perhaps worthy the attention of the court of admiralty, ſince magneſian limeſtone appears to be ſo plentifully diffuſed over the earth. See Dr. Black's Exper. on Magneſia in the Eſſay Philoſ. and Literary, Edinb.

The lime from Breedon is magneſian, that from Ticknal (which is ſold) is calcareous lime I believe; and ſome farmers in the vicinity of Derby aſſert, that two loads of Breedon lime will *go as far*, that is will apparently do as much ſervice to their land as three loads of Ticknal lime. Breedon lime, I am alſo informed, is preferred in architecture, and is ſaid to *go further* in making mortar; which I ſuppoſe means, that it requires more ſand to be mixed with it. Mr. Marſhall in his account of the agriculture of the Midland counties ſpeaks of lime made at Breedon near Derby as deſtructive to vegetables when uſed in large quantities. And in Nottinghamſhire it is aſſerted, that the lime from Critch in Derbyſhire is ſo mild, that thiſtles and graſs ſpring up through the edges of large heaps of it, when laid in the fields. Dr. Fenwick of Newcaſtle obſerves, that the farmers in that country divide lime into hot and mild; which Mr. Tennant believes to mean magneſian and calcareous lime.

By experiments which were made by Mr. Tennant by ſowing ſeeds of colewort on various mixtures of calcined magneſia with ſoil, and of calcareous lime with soil, he found that thirty or forty grains of lime did not retard the growth of seeds more than three or four of calcined magnesia; from hence what can we conclude? but that, as they both injure vegetation in large quantities, they may both assist vegetation in small ones? and that this is more probable, as the farmers believe, that they find both of them useful, though in different quantities; and as the magnesia would form Epsom salt, if it meets with vitriolic acid, which Dr. Home found from his experiments to be friendly to vegetation, when used in very small quantities. More accurate observations and more numerous experiments on this subject are required, which this important discovery of Mr. Tennant's will I hope soon occasion.

13. *To be inserted at p.* 286, *l.* 16, *at the end of No.* 2 *of Sect.* XII.

Another method has been attempted by some for the purpose of ameliorating clayey lands, which were unfit to be turned up deeper than they had been accustomed to be ploughed, on account of their acidity or tenacity being very injurious to vegetation; as the white saggar clays over many coal countries; or some very tenacious red clays, which may contain a vitriol of iron; not an oxyde, or oxygenated calx of it.

The method I allude to consists in first turning over a ridge of earth, as in common ploughing; and then with a plough, made on purpose, to penetrate some inches deeper into the clay so injurious to vegetation; this plough is to be so contrived, as to raise up the clayey soil about the breadth of the furrow recently made, and three or four inches deep, or more; but not to turn it over, so that it may still lie under the fertile soil, which is to be turned over it with the common plough, in making the adjoining furrow. So that this plough

plough is only to pafs under the foil, and thus loofen it, and mix it with atmofpheric air without turning it over.

By this manœuvre the clay a few inches deep beneath the fertile foil becomes broken in its texture, and obtains fome air intercepted in its pores; from the former circumftance it may contribute to retain the vernal fhowers, which would otherwife run off over the clayey furface beneath the more fertile one, and might thus in drier feafons prevent the upper furface from being fo much indurated, and might gradually become lefs injurious by the frequent admixture of atmofpheric air, and at length even falubrious to the roots of vegetables.

APPENDIX.

IMPROVEMENT OF THE DRILL PLOUGH.

The firft experiment I tried to improve this valuable machine was that mentioned in Sect. XII. 5. of this work, by enlarging the axis of Mr. Tull's feed-box into a wheel of fixteen inches diameter, with excavations in the rim to raife portions of the corn above the furface of that in the feed-box. But I found to my furprife the friction of the corn to be fo much greater than expected, when fix fuch large wheels were immerfed in it, that an additional hopper became neceffary to deliver the feed flowly into the feed-box, as in Mr. Cook's drill plough; which, as it would add much to the intricacy and expence of the machinery, and to the inaccuracy of the quantity of feed delivered, occafioned me to relinquifh that idea, and after many defigns and many experiments to conftruct the following machine, which I believe to be more fimple, and confequently lefs expenfive to conftruct, and lefs liable to be out of order, and to deliver the feeds of all kinds with greater accuracy than any drill plough at prefent in ufe; and that it poffeffes every other advantage that they can boaft. The fcale of the three following plates is half an inch to ten inches.

Conftruction of the Carriage Part.

Plate X. Fig. 1. *a a*, are the fhafts for the horfe, which are fixed to the center of the axle-tree by a fimple univerfal joint at *z*, whence,

4 if

if the horſe ſwerve from a ſtraight line, or is purpoſely made to paſs obliquely to avoid treading on the rows of corn in hoeing; the perſon, who guides the plough behind, may keep the coulters of the plough or hoe in any line he pleaſes; which is thus performed with much ſimpler mechaniſm, than that uſed in Mr. Cook's patent plough for the ſame purpoſe, which has many joints like a parallel rule.

b b are the horns or ſhafts behind, for the perſon who guides the drill coulters or hoes; they are fixed to the axle-tree before, and have a croſs piece about ſix inches from it at *g g* for the purpoſe of ſupporting the ſeed-box deſcribed below. Behind this about a foot diſtant from it is another croſs piece at *c c*, called the coulter-beam, which is fifty inches long, ſix inches wide, and two inches thick; it is perforated with two ſets of ſquare holes, ſix in each ſet, to receive the coulters in drill-ploughing, and the hoes in horſe-hoeing.

The ſix light ſquare holes are nine inches from each other, and are to receive the coulters or hoes in the cultivation of wheat, the rows of which are deſigned to be nine inches from each other, and the ſix dark ſquare holes are placed ſeven inches from each other to receive the coulters or hoes for the cultivation of barley, the rows of which are deſigned to be but ſeven inches diſtant from each other.

Beſides theſe there are ſix round holes through this coulter-beam at one part of it, and ſix iron circular ſtaples fixed into the edge of the other part of it; theſe are to receive the ends of the tin flues, which croſs each other, and convey the ſeed from the bottom of the ſeed-box into the drills or furrows, when the coulters are diſpoſed in the ſquare perforations before them.

Theſe coulters or hoes the perſon, who guides the machine, can raiſe out of the ground in turning at the ends of the lands, or in paſſing to or from the field, and can ſuſpend them ſo raiſed on the iron ſprings *d d*, which at the ſame time ſo fixes the *ſhafts* to the axle-

tree

tree that the wheels will then follow in the ſame line with the horſe.

e e are wheels of four feet in diameter, the nave of one of which has on it a caſt-iron wheel at *f f*, for the purpoſe of turning the axis of the ſeed-box, which has a ſimilar wheel of one fourth its diameter; whence the axis of the ſeed-box revolves four times to one revolution of the wheel.

Conſtruction of the ſeed-box. Plate XI. Fig. 2.

This conſiſts of boards about an inch in thickneſs, is forty-eight inches long within, twelve inches deep, twelve inches wide at top, and ſix inches wide at bottom; it is divided into ſix cells, in which the corn is to be put, as repreſented in Plate XI. Fig. 2. and ſhould alſo have a cover with hinges to keep out the rain, and is to be placed in part over, and in part before, the axle-tree of the carriage, at *g g*. Plate X. Fig. 1.

Beneath the bottom of the ſeed-box paſſes a wooden cylinder, at *h h*, Plate XI. Fig. 2. with excavations in its periphery to receive the grain from the ſix cells of the ſeed-box, *l m n o p q*, and to deliver it into the ſix oblique flues *i i*, which are made of tin, and croſs each other, as repreſented in the plate. The uſe of the ſeed-flues thus interſecting each other is to increaſe the length of the inclined ſurface, on which the ſeed deſcends, that if ſix or eight grains be delivered together, they might ſo ſeparate by their friction in deſcending, as not to be ſown together in one point, which might be liable to produce tuſſocks of corn.

As theſe ſeed-flues croſs each other, before they paſs through the coulter-beam at *c c*, Plate X. Fig. 1. it was neceſſary to make three of the round holes of the coulter-beam at one end backwarder than thoſe at the other end; and on that account to uſe iron ſtaples or rings at one end inſtead of perforations, as at *w w*, Plate X. Fig. 1. Theſe tin flues deliver the ſeed at the time of ſowing into the ſmall furrows or drills, which are made by the coulters before them.

Theſe ſeed-flues have a joint at *z z*, where one part of the tin tubes ſlides into the other part, and they by theſe means can be occaſionally ſhortened or lengthened to accomodate them to the coulters, when placed at ſeven inches diſtance for ſowing barley, or at nine for ſowing wheat.

At the bottom of this ſeed-box are ſix holes, one in each cell, to deliver the corn into the excavations of the cylinder, which revolves beneath them. Theſe holes are furniſhed on the deſcending ſide, as the cylinder revolves, with a ſtrong bruſh of briſtles about three fourths of an inch long, which preſs hard on the tin cylinder. On the aſcending ſide of the revolving cylinder the holes at the bottom of the ſeed-box are furniſhed with a piece of ſtrong ſhoe-ſoal leather, which rubs upon the aſcending ſide of the cylinder. By theſe means the corn, whether beans or wheat, is nicely delivered, as the axis revolves, without any of them being cut or bruiſed.

Conſtruction of the iron axis and wooden cylinder beneath the ſeed-box. Plate XI. Fig. 3.

An iron bar is firſt made about four feet ſix inches in length, and an inch ſquare, which ought to weigh about fifteen pounds; this bar is covered with wood, ſo as to make a cylinder four feet long, and two inches in diameter, as at *k k*, Plate XI. Fig. 3. The uſe of the iron bar in the centre of the wood is to prevent it from warping, which is a matter of great conſequence.

This wooden cylinder paſſes beneath the bottom of the ſeed-box, and has a caſt-iron cog-wheel at one end of its axis, as at *r r*, which is one fourth of the diameter of the correſpondent caſt-iron wheel, which

which is fixed on the nave of the carriage-wheel, as in Plate X. Fig. 1. *ff*, ſo that the axis of the ſeed-box revolves four times during every revolution of the wheels of the carriage.

In the periphery of this wooden cylinder are excavated four lines of holes, ſix in each line, as at *n n n n n n*. A ſecond line of excavations is made oppoſite to theſe on the other ſide of the cylinder, and two other lines of excavations between theſe ; ſo that there are in all twenty-four excavations in the wooden part of this axis beneath the ſeed-box, which excavations receive the corn from the ſeed-cells, as the axis revolves, and deliver it into the flues ſhewn in Plate XI. Fig. 2. *ooii*, not unſimilar to the original deſign of the ingenious Mr. Tull.

The ſize of theſe excavations in the wooden cylinder to receive the ſeed are an inch long, half an inch wide, and three eighths of an inch deep ; which are too large for any ſeeds at preſent employed in large quantities except beans, but have a method to contract them to any dimenſions required, by moving the tin cylinder over the wooden one, as explained below in Plate XI. Fig. 4.

Conſtruction of the Tin-cylinder. Plate XI.

A B at Fig. 4. repreſents a cylinder of tin an inch longer within than the wooden cylinder on the iron axis at Fig. 3. and is of two inches diameter within, ſo as exactly to receive the wooden cylinder, which may ſlide about an inch backwards or forwards within it. C D are two ſquare tin ſockets fixed on the ends of the tin cylinder to fit on the ſquare part of the iron axis, which paſſes through the wooden cylinder at *ll*, Fig. 3. on which they ſlide one inch backwards or forwards.

The following directions in making the holes in this tin cylinder, and thofe in the wooden cylinder, which are to correfpond with them, muft be nicely attended to.

Firft, when the tin-cylinder is foldered longitudinally, and one end of it foldered on, as at A, fix holes through it muft be made longitudinally on four oppofite fides of it, each hole muft be exactly half an inch wide, and five eighths of an inch long, the length to be parallel to the length of the cylinder.

The centre of the firft of thefe holes muft be five inches diftant from the clofed end A, the centre of the fecond hole muft be eight inches diftant from the centre of the firft, and fo on till fix holes are made longitudinally along the cylinder. Then another fuch line of fix fimilar-holes is to be made on the oppofite fide of the cylinder, and then two other fuch lines between the former, in all twenty-four; and the fize of all thefe holes muft be nicely obferved, as well as their diftances.

Secondly. The wooden cylinder fixed on the axis is now to be introduced into the tin cylinder, but not quite to the end of it, but fo as to leave exactly one inch of void fpace at the clofed end A, and then the fize of all thefe apertures through the tin cylinder, each of which is exactly half an inch wide, and five eighths of an inch long, are to be nicely marked with a fine point on the wooden cylinder, which muft not previoufly have any excavations made in it.

Thirdly. The twenty-four holes thus marked on the wooden cylinder are now to be excavated exactly three eighths of an inch deep, but with an addition alfo of three eighths of an inch at that end of every one of them which is next to A; fo that, when the wooden cylinder is again replaced in the tin cylinder as before, with one inch of void fpace at the clofed extremity of it, the excavations in the wooden cylinder will be three eights of an inch longer, than the perforations in the tin cylinder over them. Thefe excavations in the wooden cylinder muft alfo be rather narrower at the bottom than at the

the top, to prevent with certainty any of the grain from ſticking in them, as they revolve.

Fourthly. A ſcrew of iron about three inches long, with a ſquare head to receive a ſcrew-driver, is to paſs through the end A of the tin cylinder on one ſide of the axis, as at x, Fig. 4. The ſcrew part of this is to lie in a hollow groove of the wooden cylinder, and to be received into a nut, or female ſcrew, which is fixed to the wooden cylinder. The head part of the ſcrew, which paſſes through the end A of the tin cylinder at x, muſt have a ſhoulder within the tin cylinder, that it may not come forwards through the end of it; and a braſs ring muſt be put over the ſquare end of the ſcrew on the outſide of the tin cylinder, with a pin through that ſquare end of the ſcrew to hold on the braſs ring.

Thus when the ſquare head of the ſcrew is turned by a ſcrew-driver, it gradually moves the tin cylinder backwards and forwards one inch on the wooden one, ſo as either to preſs the end A of the tin cylinder into contact with the end of the wooden cylinder within it, or to remove it to the diſtance of one inch from it, and leave a void ſpace at the end A.

Fifthly. The ends of all the holes of the tin cylinder, which are next to the end A of it, are now to be enlarged, by ſlitting the tin three eighths of an inch towards A, on each ſide of the hole; and then that part of the tin, included between theſe two ſlits, which will be half an inch wide, and three eighths of an inch lengthways in reſpect to the cylinder, is not to be cut out, but to be bent down into the excavations of the wooden cylinder beneath, ſo as to lie againſt that end of the excavation which is next to A.

But theſe projecting bits of tin, before they are bent down into the excavations of the wooden cylinder, muſt be filed a little leſs at the projecting end, which is to be bent down, than at the other end; as the excavations of the wooden cylinder are to be rather narrower at the bottom than at the top, and theſe pieces of tin, when bent down, muſt exactly fit them.

Laſtly. When all theſe holes through the tin-cylinder are thus enlarged, and the bits of tin filed rather narrower at their projecting ends, and then bent down into the excavations of the wooden cylinder, the other end of the tin cylinder with its ſquare ſocket may be ſoldered on.

And now when the end of the tin cylinder at A is preſſed forwards upon the wooden cylinder towards B, by turning the ſcrew at *x* above deſcribed; every excavation of the wooden cylinder will be gradually leſſened, and finally quite cloſed; by which eaſy means they may be adapted to receive and deliver ſeeds of any ſize from horſe-beans and peas to wheat, barley, and to turnip-ſeed, with the greateſt accuracy, ſo as to ſow four, five, or ſix pecks on an acre, or more or leſs, as the agricultor pleaſes, by only turning the ſcrew a few revolutions one way or the other.

Obſervations.

1. In the conſtruction of the tin and wooden cylinders beneath the ſeed-box another ſmall improvement may be neceſſary in ſowing very ſmall ſeeds, which is this: As the ſcrew at the end A is turned, ſo as to contract all the excavations of the wooden cylinder, the ſurface of the wooden cylinder for one inch from the end of each excavation towards the end B, Plate XI. Fig. 4. will become bare without being covered by the tin cylinder; and on theſe bare parts of the wooden cylinder, which will be one inch long, and half an inch wide, ſome ſmall ſeeds may chance to ſtick, and evade the bruſhes, which ſhould prevent them from paſſing, as the cylinders revolve.

To prevent this, when the wooden cylinder is ſo placed within the tin cylinder, that all the holes are quite open, let a piece of the tin cylinder

cylinder about an inch and a half long, and half an inch wide, be cut out from the extremity of each hole next to the end B, and let this piece of the tin cylinder thus cut out be fixed by a few fprigs on the wooden cylinder exactly in the fame place, which it covered before it was cut out of the tin one, by which contrivance, when the tin cylinder is afterwards pufhed forwards by turning the fcrew at its end, fo as to contract the excavations of the wooden cylinder beneath, the bare parts of the wooden cylinder will exift an inch and a half from the extremities of the excavations next to the end B, and thus will not pafs under the brufhes, and in confequence no fmall feeds can lodge in them.

2. Some kind of iron ftaple fhould be fixed at each end of the feed-box on the outfide, which when the hinder part of the carriage is raifed up by the perfon who guides it, might catch hold of the two iron fprings at *dd* in Plate X. Fig. 1. for the purpofe of fufpending the coulters out of the ground, and connecting the hinder part of the machine with the fhafts before; that in turning at the ends of the lands, or in paffing from or to the field, the wheels may not fwerve at the joint *z*, at the centre of the axle-tree, but may follow in the fame line with the fhafts.

3. The feed-box muft alfo be fupported on upright iron pins paffing through iron ftaples, with a lever under the end of it next to the wheel *rr*, Plate XI. Fig. 3. for the purpofe of eafily lifting that end of the feed-box about an inch high, to raife the teeth of the iron cog-wheel on its axis out of the teeth of the correfpondent iron wheel on the nave of the carriage-wheel.

4. The conftruction of the coulters, which make the drills, and of the rakes, which again fill them, after the feed is depofited, and alfo of the hoes, are not here delineated; as they are fimilar to thofe fo often defcribed or ufed by Mr. Tull and his followers.

5. When the lower ends of the feed-flues are placed through the holes in the coulter-beam, Plate I. Fig. 1. at nine inches diftance

from

from each other, the rows of wheat or beans will then be ſown nine inches from each other; and as the wheels of the carriage are four feet in diameter, and therefore travel about twelve feet at each revolution; and as there are four excavations round the axis of the ſeed-box, which revolve four times for one revolution of the carriage-wheels; it follows, that the ſeeds contained in the excavations of the cylinder beneath the ſeed-box will be ſown at nine inches diſtance in each drill or furrow, as the plough proceeds; and as theſe rows are nine inches aſunder, any deſired number of ſeeds may be depoſited in every ſquare of nine inches, which are contained in the ſurface of the field.

6. Mr. Coke of Norfolk acquainted me, that on his very extenſive farm the wheat ſown on an acre was ſix or ſeven pecks by the Rev. Mr. Cook's drill plough, which was about half the quantity generally uſed in broad-caſt ſowing. If the wheat was nicely depoſited in the drills, I ſuſpect one buſhel would be quite ſufficient for an acre, as the rows are at nine inches diſtant from each other; for there would in that caſe be about eight grains or nine grains depoſited in every nine inches of the drill-furrow; that is, in every ſquare of nine inches contained in the ſurface of the land ſo cultivated.

Which may be thus eſtimated. Mr. Charles Miller, in the Philoſophical Tranſactions, Vol. LVIII. p. 203, has eſtimated the number of grains in a buſhel of wheat to amount to 620,000; and Mr. Swanwick of Derby has lately eſtimated them to be 645,000. We may ſuppoſe therefore, that a buſhel may at an average contain 635,000 grains of wheat. Now as a ſtatute acre contains 4840 ſquare yards, and there are ſixteen ſquares of nine inches in every ſquare yard, 4840 multiplied by 16 gives 77,440, which is the number of ſquares of nine inches in ſuch an acre. If 635,000 grains in a buſhel be divided by 77,440, the number of ſquares of nine inches in an acre, the quotient will ſhew, that rather more than eight

eight grains of wheat will thus be depoſited in every nine inches of the drills.

7. Now if eight or nine grains were dropped altogether in one inch of ground, they would be too numerous, if they be all ſuppoſed to grow, and would form a tuſſock; but by making them ſlide down an inclined plane, as in the tin-flues, from the ſeed-box to the coulters, which are croſſed for the purpoſe of lengthening them, as ſeen in Plate XI. fig. 2. ſome of the ſeeds will be more delayed by their friction in deſcending than others, and the eight or nine ſeeds will thence be diſperſed over the whole nine inches of the drill; which renders drill-ſowing ſuperior to dibbling, as in the latter the ſeeds are dropped all together.

8. When the holes in the wooden cylinder are completely open, they are about a proper ſize for ſowing horſe-beans or peas: when they are completely cloſed, there will remain a ſmall niche at the end of the excavation in the wooden cylinder next to B, Plate XI. fig. 4. for turnip-ſeed, or other ſmall ſeeds.

For wheat and barley and oats, a wooden wedge ſhould be made of the exact ſhape of the area of the hole, which the director of the plough requires; who will occaſionally inſert it into the holes, when he turns the ſcrew at the end of the cylinder to enlarge or to leſſen them to theſe exact dimenſions.

Theſe wedges ſhould be written upon with white paint, wheat, barley, oats, &c. which will much facilitate the adapting the ſize of the excavations to each kind of grain, and may be altered, if required, to ſuit larger or leſs ſeeds of the ſame denomination.

9. In ſome drill-ploughs, as in Mr. Cook's, there is an additional machinery to mark a line, as the plough proceeds, in which the wheel neareſt the laſt ſown furrow may be directed to paſs at a proper diſtance from it, and parallel to it. But in ſowing wheat or peas and beans this may be done by making the wheels, as they run upon the ground, to be exactly fifty-four inches from each other; and

then at the time of ſowing to guide the wheel next to the part laſt ſown exactly in the rut, which was laſt made; by which guide the rows will all of them be accurately at nine inches diſtant from each other.

The Simplicity of this Drill-Plough.

1. The ſimplicity of this machine conſiſts firſt in its having only a feed-box, and not both a hopper and a ſeed-box, as in the Rev. Mr. Cook's patent drill-plough.

2. The flues, which conduct the ſeed from the bottom of the ſeed-box into the drill-furrows, are not disjoined about the middle of them to permit the lower part to move to the right or left, when the horſe ſwerves from the line, in which the coulters paſs, as in Mr. Cook's patent drill-plough; which is done in this machine by the ſimple univerſal joint at z, Plate I. fig. 1.

3. In this machine the horns or ſhafts behind, between which the perſon walks, who guides the coulters, are fixed both to the coulter-beam, and to the axle-tree; whereas in Mr. Cook's patent plough theſe are all of them moveable joints like a parallel rule, for the purpoſe of counteracting the ſwerving of the horſe; which in this machine is done by the ſimple univerſal joint at z, fig. 1, Plate I. before mentioned.

4. The altering the dimenſions of the holes in the axis of the ſeed-box by only turning a ſcrew, ſo as to adapt them to all kinds of ſeeds, which are uſually ſown on field-lands.

5. The ſtrong bruſh of briſtles, which ſweep over the excavations of the cylinders beneath the ſeed-box, ſtrickle them with ſuch exactneſs, that no ſupernumerary ſeeds eſcape, and yet none of them are

in the leaſt bruiſed or broken, as I believe is liable to occur in Mr. Tull's original machine.

Laſtly it ſhould be obſerved, that the leſs expence in the conſtruction, the leſs propenſity to be out of repair, and the greater eaſe of underſtanding the management of this machine, correſpond with its greater ſimplicity; and will, I hope, facilitate the uſe of the drill-huſbandry.

Mr. Swanwick's Seed-Box.

As the dibbling of wheat, deſcribed in Sect. XVI. 2. 2. is a very ſlow and laborious method of depoſiting the corn, and is yet coming, as I am informed, more and more into faſhion in ſome counties, I ſuſpect this muſt be owing to the expence of procuring, and the difficulty of managing the drill-ploughs now in uſe, or to the greater inaccuracy, with which they deliver the ſeed. I flatter myſelf therefore, that I am doing a benefit to ſociety in endeavouring to ſimplify this machine, and to increaſe its accuracy as much as poſſible: and ſhall therefore here deſcribe another method of delivering the ſeed from the ſeed-box, which was invented by Mr. Swanwick, an ingenious teacher of writing and arithmetic, with ſome branches of natural philoſophy, in Derby; and who will not be averſe to ſhew the working models of the ſeed-boxes, or to give aſſiſtance to any one, who wiſhes to conſtruct either this drill machine, or the preceding one.

Mr. Swanwick's ſeed-box is forty-eight inches long within, is divided into ſix cells for the purpoſe of ſowing ſix rows of ſeeds at the ſame time, like that above deſcribed. And at the bottom of each cell is a hole *a*, *a*, &c. Fig. 1. Plate XII. for the ſeed to paſs

 through

through into the feed-flues, as in the machine before defcribed: but in this there is no revolving axis, but a wooden or iron bar B B, fig. 3. Plate XII. about two inches broad, and about four feet eight inches long, and exactly three eighths of an inch thick. Through this bar there are fix perforations, *e e e*, &c. which are each of them exactly one inch long, and half an inch wide; and three eighths of an inch deep, which is the thicknefs of the bar. The centres of thefe holes are exactly eight inches diftant from each other, correfpondent to the holes at the bottom of the feed-box; over which it is made to flide backward and forwards in a groove. By this fliding motion it paffes under ftiff brufhes, which are placed over it on each end of the holes at the bottom of the feed-box, and ftrickle off the grain, as the holes in the fliding-bar pafs under them, which thus meafure out the quantity with confiderable accuracy.

In order to increafe or diminifh the quantity of grain delivered, the flider is covered with a cafe of tin C C, fig. 4, Plate XII. which has fix perforations exactly correfponding with the holes in the flider; but inftead of the bit of tin being cut out the whole length of the hole, part of it is left at the end *i*, fig. 6, equal to the thicknefs of the flider, and is bent down as at *h*, after the flider is put into the cafe, like the tin cylinder in the preceding machine. This cafe is moveable about one inch backward and forward by turning the finger fcrew *s*, fig. 4 and 5; and thus the holes are made larger or lefs to fuit various forts of grain, or different quantities of the fame fort, exactly as in the wooden and tin cylinders in Plate XI. The flider is moved forwards by a bent iron pin *b* attached to it, which paffes into a ferpentine groove Y, fig. 5, fixed to the nave of the wheel: and backwards by a fteel fpring at the other end of the feed-box, which is not reprefented in the plate.

Fig. 5 is a bird's eye view of the parts before defcribed: E E the feed-box divided into cells by the partitions *d d*, &c.—*c c c* the flider, with

I

with a part of the apertures feen juft appearing from under the brufhes. X the axis of the wheel.

Fig. 6 is a drawing of part of the tin cafe, nearly of the full dimenfions as to breadth and thicknefs, but only a fmall portion of the length; and is intended to fhew more diftinctly the conftruction of it.

Fig. 2 reprefents a fide-view of one of the fix bridges lying over the holes at the bottom of the feed-box, on each fide of which the brufhes are fixed, which ftrickle the holes, when they are full of corn, as the bar flides backwards and forwards.

The fimplicity of this flider at the bottom of the feed-box may be in fome refpects greater, than that of wooden and tin cylinders in the former machine; as this has but fix holes to meafure out the corn, and the other has twenty-four. But perhaps in other refpects lefs fo; as in this twelve brufhes are ufed, one on each fide of each of the fix holes; whereas there are only fix brufhes rub upon the tin cylinder in the former machine. And the reciprocating motion of this flider muft be quick, as it muft act once every time the periphery of the wheel of the carriage has paffed nine inches forward; which may not be fo eafy to execute as the cog-wheel, and uninterrupted movement of the axis and cylinder in the preceding machine.

I have only to add, that the facility of adapting the holes to the dimenfions required in both thefe machines, and their not bruifing or breaking the grain in their operation of delivering it, as well as their not being encumbered with an additional hopper, which muft deliver the quantity of feed with great inaccuracy from the unequal fhaking of the machine, adds much to the excellency and fimplicity of them both. And I hope will render more general the ufe of the drill hufbandry invented by the ingenious Mr. Tull; who was on that account an honour to this country, and ought to have a ſtatue erected to his memory, as a benefactor of mankind, like Ceres and Triptolemus of old.

Ille Ego, qui quondam gracili modulatus avena
Carmen, et egreſſus ſylvis vicina coegi,
Ut quamvis avido parerent arva colono.

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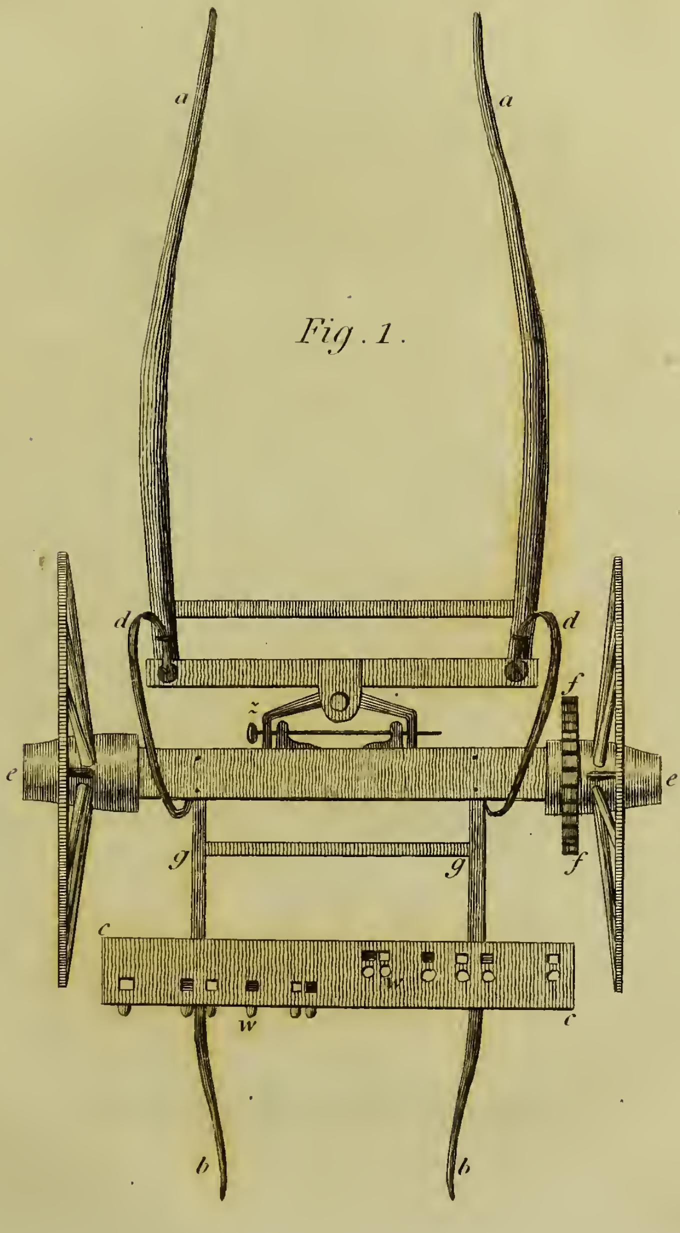

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Plate XI.

Fig. 2.

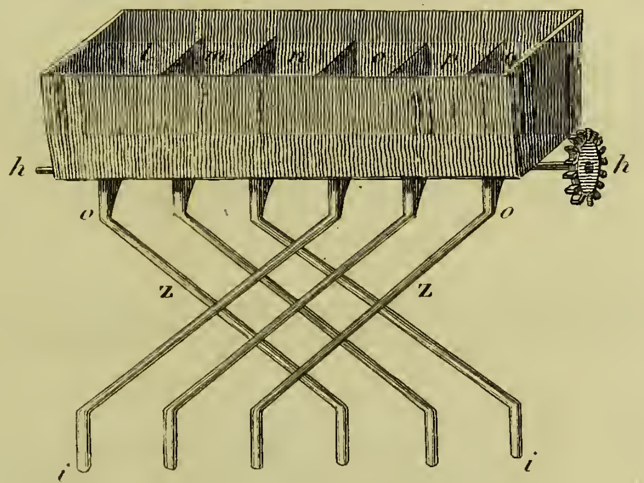

Fig. 3.

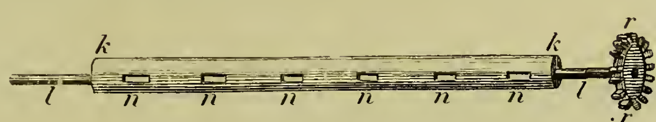

Fig. 4.

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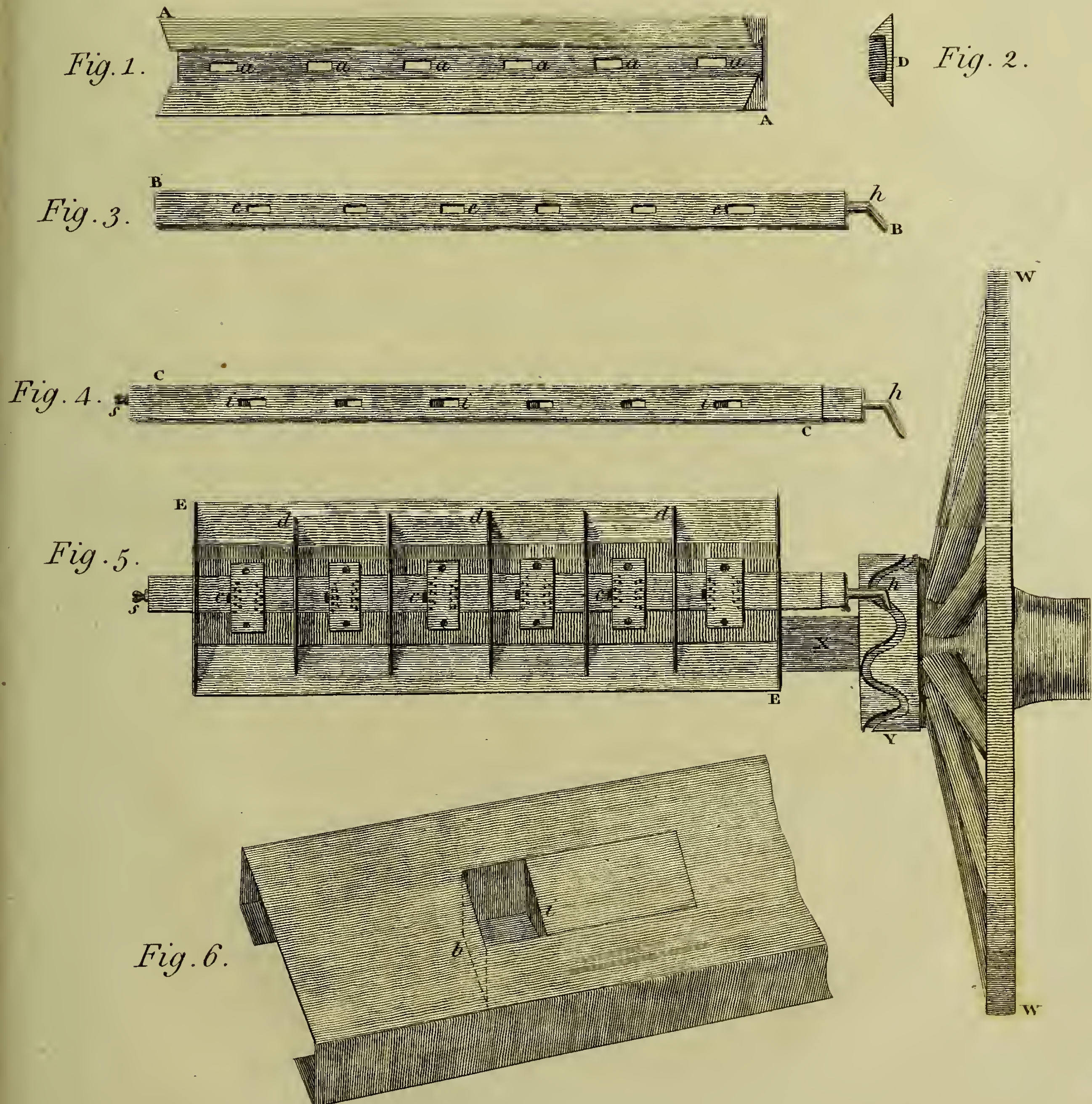
Plate XII.



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I N D E X.

Barks

Colouring,

Flax

G.

Growth

Spur

U. Umbilical

U.

V.

W.

Wines,

INDEX.

THE END.

ERRATA.

Page 139, line last but one, *read* distinguishes, *for* distinguish.
—— 121, line 14, *for* from, *read* form.
—— 528, line last but two, *for* so, *read* no.

DIRECTIONS TO THE BINDER.

Please to put Plate I. and the Explanation of it, facing each other, at the end of Section I. between pages 8 and 9.

Plate II. at the end of Sect. II. between p. 18 and 19.

Plate III. at the end of Sect. III. between p. 38 and 39.

Plate IV. at the end of Sect. IX. between p. 182 and 183.

Plate V. VI. VII. at the end of Sect. XI. between p. 282 and 283.

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Plate IX. at the end of Sect. XIV. between p. 372 and 373.

Plate X. XI. XII. at the end.

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